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The Copenhagen Conference of the International Astronomical Union*

By OTTO STRUVE

I

We arrived at the Copenhagen airport in a blinding snow-storm. Because of unfavorable weather conditions our plane was delayed at almost every stop. Hence we arrived late in the evening of March 7 and missed the opening session of the meeting and the reception to delegates given by the Royal Danish Academy of Sciences and Letters. The official business of the conference started on the 8th and ended on the 12th.

Invitations to the conference had been extended several months earlier by the Executive Committee of the Union. This committee consists of the President, the five Vice-Presidents, and the General Secretary. At the last pre-war meeting, in Stockholm, Sir Arthur Eddington was elected President, Messrs. G. Abetti, W. S. Admas, Ö. Bergstrand, W. Brunner, and C. Fabry as Vice-Presidents, and J. H. Oort as General Secretary. During the war Dr. Adams temporarily took over the responsibilities of the General Secretary, but since the liberation of Europe Dr. Oort has again assumed his regular duties. After the death of Professor Eddington, the Executive Committee elected Sir Harold Spencer Jones, the Astronomer Royal, to be the President of the Union until a new Executive Committee is elected by the first post-war general assembly of the Union.

The Copenhagen conference had no legal status under the constitution of the Union, other than as a meeting of the Executive Committee. Prior to the meeting, Dr. A. Danjon, Director of the Paris Observatory, had been elected Vice-President, in place of the deceased Professor Fabry, and, during the meeting, Professor A. A. Mikhailov, of Moscow, was coopted as Vice-President. Present at Copenhagen were the following members of the Executive Committee: Spencer Jones, Oort, Danjon, and Mikhailov. In addition, Professor Joel Stebbins acted as the representative of Dr. Adams and Dr. B. Lindblad replaced Professor Bergstrand.

*This report is an informal account of the results of the Copenhagen conference, and the responsibility for the interpretations rests upon me alone. An official statement of the decisions reached by the Executive Committee of the Union will undoubtedly be issued by the General Secretary in due course.

Since many important questions had come before the Union, the Executive Committee had invited a number of delegates from various countries to come to Copenhagen. The selection of the individual delegates was made by the various national committees. In the United States, Dr. Harlow Shapley is chairman of the national committee while Messrs. Adams, Hubble, McLaughlin, Schilt, and Stebbins constitute the membership. The American national committee appointed as delegates to Copenhagen Dr. Shapley, Dr. Stebbins, and the writer of this report.

Thirteen countries were represented at Copenhagen: Belgium (Delporte), Czechoslovakia (Link), Denmark (E. Strömgren, Hertzsprung, Nørlund, and B. Strömgren), France (d'Azambuja, Danjon, and Fayet), Great Britain (Greaves, Spencer Jones, and Stratton), Netherlands (Minnaert and Oort), Norway (Randers), Poland (Banachiewicz and Witkowski), Sweden (Lindblad), Switzerland (Guyot), U.S.A. (Shapley, Stebbins, and Struve), USSR (Mikhailov and Shajn), Vatican City State (Junkes). During the first session several working committees were formed to deal with specific questions proposed by the Executive Committee. These temporary groups, whose functions expired after they had prepared their reports were as follows:

1. *Variable Stars:* Shapley, Danjon, Shajn, Hertzsprung.
2. *Solar Phenomena:* d'Azambuja, Minnaert, Stratton, Stebbins, B. Strömgren.
3. *Fundamental Astronomy and Minor Planets:* Danjon, Delporte, Fayet, Guyot, Mikhailov, Struve, Spencer Jones.
4. *Nominations for Regular Standing Committees of the Union:* Chairman: Danjon, Members: Delporte, Link, B. Strömgren, Greaves, Minnaert, Randers, Banachiewicz, Lindblad, Guyot, Struve, Mikhailov, Junkes.
5. *Bibliography and Related Subjects:* d'Azambuja, Delporte, Greaves, Minnaert, E. Strömgren, Struve, Shapley.

It was decided that all members of the conference would have free access to the meetings of these groups, and this privilege was very freely used. The principal results of the deliberation of the conference as a whole, and of the five working committees, were as follows:

1. The time of the next general assembly was not definitely determined, but there was an almost unanimous feeling that it should not be held earlier than in 1948. No decision was reached as to the place. The invitation from Switzerland issued at the 1938 meeting is still in force. But it is quite possible that conditions will compel the Executive Committee to choose another country.

2. There will be no major changes in the structure of the Union or its activities. Adherence will be by countries and the financial contributions will be fixed as heretofore. Several delegates thought that the amounts of the contributions and the numbers of votes for each

should be approximately proportional to the numbers of astronomers from each country admitted to membership, but this idea was opposed on the ground that it might result in the "buying of votes" by some countries. It was also felt that this system would unduly penalize those nations which, like the United States, Great Britain, or France, have large numbers of astronomers. Under the present system the basic factor is the population of each country. The membership of the Union will consist, as heretofore, of all persons who have been elected to any of the standing commissions or have been coopted between the general assemblies to such commissions, and of other persons, not necessarily belonging to standing commissions, who have been nominated by adhering organizations or by national committees. But it was felt that the members of the national committees should not automatically be members of the Union, because there appears to be a large discrepancy between different countries in the qualifications required for belonging to a national committee.

3. Among the activities of the Union one of the most important will be the work of a new standing commission (No. 38) on the exchange of astronomers. The chairman is Professor F. J. M. Stratton of Cambridge, England, and the members are: Y. C. Chang, Danjon, Dawson, Lindblad, Minnaert, Shajn, Struve, Van den Bos, and Witkowski. This commission will work in contact with the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and will act as an advisory body to which UNESCO could refer questions regarding the exchange of astronomers. It is to be hoped that efforts to bring about exchanges of astronomers will be made at once.

4. During the first general session at Copenhagen Professor J. Witkowski proposed in the name of the Polish delegation the creation of an international observatory, where astronomers from many countries—presumably mostly European—could obtain observational data. This remarkable suggestion found immediate and unanimous support, especially in view of an inspired plea for just such an observatory by Dr. Shapley. Unknown to the Polish delegates, Dr. Shapley had already at the time of the recent Copernicus celebrations advocated the creation of an international "Copernican Memorial Observatory," somewhere in southern or south-eastern Europe[1] and has since then vigorously upheld the plan before UNESCO, of which he was one of the original members for the United States at its London conference. A somewhat related proposal was made by Dr. Delporte on behalf of the Belgian astronomers. This plan, though apparently first conceived as a new Belgian observatory in the Congo, could, according to Dr. Delporte, be modified to satisfy some of the suggestions made by Dr. Witkowski.

5. One of the burning questions of the present time is which organization will assume the responsibility for issuing catalogues of vari-

able stars, for scrutinizing and naming new variables and for acting as headquarters of variable-star research. Before the war most of these tasks were concentrated in the commission on variable stars of the *Astronomische Gesellschaft,* and annual catalogues were published by the Berlin-Babelsberg Observatory, first under the supervision of R. Prager, and more recently of H. Schneller. Because of the disruption of the work of the German observatories it was decided that Commission 27 of the Union will be responsible for the naming of variables, and for the publication, every five years, of complete catalogues of all known variables, with intervening annual supplements. The Sternberg Astronomical Institute in Moscow will prepare the name-lists and will carry out much of the actual work, with a subcommittee of Commission 27 acting in an advisory capacity. The Russian Observatory has a large and competent staff to carry on this work. The names of Kukarkin, Parenago, Martinoff, and some others are well known in this field. The Russians have already done much to assure the continuity of observational work on many important objects. Recently, they have started a new periodical in English, under the name "Variable Stars" which promises to become an important source of information. There does not seem to be any reason for concern in this regard. The Cracow Observatory will receive two annual subsidies voted in 1938, but not yet paid, in order to carry on its work in 1946-48. In connection with the problems of variable stars attention may be called to the recently formed panel of American astronomers on the orbits of eclipsing binaries. This panel, with H. N. Russell as the chairman, and Z. Kopal as the secretary, will function under the auspices of the American Section of the IAU, but may later become a subcommittee of Commission 27.

6. With regard to the asteroids the situation is equally pressing. It was decided to ask the Institute of Theoretical Astronomy at Leningrad, especially the Director, Dr. Subbotin, and the astronomer in charge of asteroids, Mrs. Samoilova-Jakhontova, to share with Professor Kopff's *Recheninstitut,* now located at Heidelberg, the responsibility for computing the ephemerides of all known asteroids. The University of California bureau at Berkeley, with Dr. Cunningham, is to be approached in regard to the determination of orbits of newly discovered asteroids. The IAU would be responsible for the publication of the orbits and ephemerides. It is my understanding, from direct conversations with the Russian delegates, that the inclusion of the Heidelberg organization was recommended by them, because they felt that the amount of work involved surpassed the resources of any single institution.

7. An animated discussion took place with regard to two important proposals in positional astronomy. The American delegation, through Dr. Shapley, supported a plan prepared by Dr. Schilt's committee of the American Astronomical Society on a "proposed international project

of determining accurate proper motions with the photographic zenith tube." The report of this committee, and Commodore Hellweg's letter of transmittal, were read in detail and were discussed in a conference of the appropriate working committee. In principle, the idea was well received, and a request was made "that an information center for this project be formed at the Naval Observatory in Washington." It was evident from the discussion that the photographic zenith tube is receiving wide acclaim, and several institutions are planning to order instruments of this type. It is being considered for India (by Dr. Banerji, Director of Observatories in India) and also for the proposed Belgian Observatory in the Congo. A grant of £900 was made to the Leiden Observatory for a second expedition to central Africa to determine fundamental declinations by means of azimuth observations, of stars near the horizon. This project, started under Professor de Sitter, is so promising that Dr. Oort wishes to continue it. Additional funds for the expedition will be raised through other means.

8. In regard to solar phenomena, grants to Meudon and Arcetri were renewed, but in the case of the latter, the Union will not continue subsidizing the publication of the *Immagini Spettroscopiche* after the records already prepared (for 1935 and 1936) have been published. Messrs. Fessenkoff, Lyot, Menzel, and Woolley were nominated to the joint commission on the ionosphere. Several questions were referred to Standing Commission No. 11, for example how best to introduce into the *Quarterly Bulletin* dealing with sunspot activity such data as records of coronal phenomena, radio static of solar origin, luminescence of the night sky, etc.

9. The working commission on bibliography recommended the continuation of the *Bibliographie Mensuelle* to provide rapid information concerning all publications of astronomical interest, and also expressed the hope that the annual volume of the *Jahresbericht,* or some other similar compilation, would be prepared regularly, even though it is recognized that there may be a considerable delay in securing its publication. Mr. Struve reported that according to Dr. Kuiper's unpublished report on German observatories various important publications, including several volumes of the *Jahresbericht* are available in Germany; A request is to be made to the Allied Occupation Authorities in Germany to secure the distribution of these volumes. In this connection it may be appropriate to remark that according to Dr. Kuiper's observations the Heidelberg *Recheninstitut* would seem to be quite capable of continuing the long series of the *Jahresbericht,* especially because Dr. Heinemann, who has been in charge of this work for some years, is with Dr. Kopff at Heidelberg. But, of course, it would be necessary for them to receive all current publications. Dr. Minnaert raised the question of publishing summarizing articles on different topics of astronomy and astrophysics. The committee welcomed the suggestion and refer-

red it to Standing Commission No. 5. Dr. Minnaert intends to pursue this question further. I believe he has in mind a series of articles somewhat along the lines of the reports which appear annually in the *Monthly Notices.* The committee discussed the question of a new edition of *Les Observatoires et les Astronomes* formerly edited by Dr. Stroobant. It was announced that a similar volume is under preparation by Dr. Lundmark. Similar data may also be given in the *Index Generalis* which, before the war, was being published every year in France. I believe that most astronomers would welcome it if Dr. Lundmark would issue a comprehensive list very soon. Even a temporary mimeographed compilation from his card-catalogue would be helpful in revising mailing lists, and even in renewing the exchange of letters between astronomers.

10. Perhaps the most difficult question before the conference was to determine the status of Germany, Japan, and other former enemy countries. Germany never adhered to the Union, but individual German astronomers were coopted members of many standing commissions. Japan did adhere to the Union and many Japanese astronomers were also members of commissions. The statutes of the Union do not provide for the expulsion of member countries or for changes in the membership of commissions, except through the process of coopting new persons. But neither do the statutes provide for such a catastrophe as the last war. It is clear that some way had to be found to deal with this question. The statutes may only be changed "with the approval of two-thirds of the votes of the adhering countries," but apparently the vote taken by countries is to be cast at a General Assembly by a person whose name has been reported by each adhering organization to the Executive Committee. The Copenhagen conference was not a General Assembly, and had no legal power. Nevertheless, its decisions—as temporary measures, to be sanctioned by the next General Assembly—will have far-reaching consequences. The discussion was opened by Spencer Jones. Then the delegates spoke, one after another, for the thirteen countries represented. Shapley reported that at a preparatory session of the American section, with a few invited guests, in New York, last February, the opinion prevailed that the decision should come principally from astronomers of the devastated countries of Europe. As I listened to the earnest voices and looked into the tense faces of the men who sat around the large table in the Academy building I was impressed with their sincerity and their deep desire to reach a fair and a wise decision. The opinions were not all alike. Broadly speaking two views were expressed. One group of delegates advocated formal expulsion of German and Japanese astronomers for different periods of time, with or without provision for some kind of machinery to test the admissibility of persons who were not "contaminated" by Nazi ideology and were not guilty of war crimes. Several persons strongly advocated

the view that a distinction should be made between persons who were "guilty" and persons who were "not guilty." If I understood the speakers correctly they suggested that the Union should either abide in this respect by the decision of an official Allied Control Commission which is supposedly now engaged in examining this very point, or should set up its own commission for this purpose. There was no one who advocated permanent expulsion, and one delegate from a devastated country especially demanded that "membership in the Union should not depend upon race, religion, or national origin, but only upon scientific honor." Another delegate, preferring that no Germans be admitted to the Union now, remarked that this would inflict suffering upon a few worthy persons, but that in a general way "there was little or no resistance to the Nazi policies among the German astronomers." The delegate from one of the three neutral countries (Sweden, Switzerland, and Vatican City State) suggested that "as far as possible normal relations be reestablished," but all three agreed with the rest of the delegates that it would be undesirable and even impossible to have the German and Japanese astronomers take part in the work of the Union at the present time. The other group preferred not to pass a formal resolution, but to accept as the unanimous concensus of the conference that for the present, at least, the memberships of the various standing commissions should be completely revised without the inclusion of German and Japanese astronomers. We must recognize the fact that we are still officially at war with both countries and that for an indefinite period of time all relations with nationals of these countries will be under the supervision of the occupation authorities. We must also be aware of the fact that many persons in the allied countries have undergone terrible suffering during the war, and their wounded feelings must be given time to heal before we can expect anything but the most formal kind of scientific contacts with astronomers in former enemy countries. I believe that those German astronomers with whom we shall sooner or later renew scientific contacts will understand and respect this view, and will probably themselves prefer that, as Spencer Jones remarked in his concluding speech, the effect of time be allowed to exert its influence. There is, then, no contradiction between the decision at Copenhagen not to include German and Japanese astronomers in the new standing commissions, and the desire expressed earlier in this report that the Heidelberg institute should continue its work on asteroids and the *Jahresbericht*.

11. The nominating committee held several long sessions, and finally proposed to the Executive Committee a completely new list of members for all standing commissions. In a general way, the prevailing attitude was to renominate the former members (elected in 1938) unless they were definitely known not to be active in the work sponsored by the commission. Hence, the task resolved itself largely to the nomina-

tion of new members. If the committee achieved a measure of success, this was largely due to the masterful handling of the work by its chairman, Dr. Danjon. Because of the large number of astronomers in the United States the work of the American delegation was especially difficult and responsible. We felt that it would have been unwise to overload the commissions with American astronomers (which would have been easy to do in several commissions). At the same time we wanted to be certain that all those who could help with the work would be remembered and that at least one person from each large observatory would be nominated. At the initiative of the British delegation the nominating committee decided to ask the Executive Committee to accept for membership all permanent residents of a country, without regard for formal naturalization. This was important in the case of several refugee German astronomers in Great Britain who, because of the war, have not yet been able to become naturalized. It is also important in the case of the United States where the Oriental exclusion law has heretofore prevented worthy persons from such countries as India to be elected to membership except through the later process of cooptation. The official list of members will be distributed in due time by Dr. Oort.

It is my personal opinion that the manner in which these selections are made is somewhat unsatisfactory. Whether we like it or not, membership in the Union has come to be regarded as a distinction. Some astronomers apparently even measure the prestige they are holding among their colleagues by the number of commissions to which they belong! Those who are not included are quite unjustly slighted. Most of them undoubtedly feel that they should refrain from taking part in the work of the Union, and some undoubtedly become antagonistic to the whole organization. The existing commissions do not cover all fields of activity, and there are some very striking omissions in the list of members, because apparently there was no suitable "pigeonhole" for such individuals among the 34 standing commissions. Some years ago the Union made it possible for astronomers to become members at large through nomination by the national committees. This procedure has not been used to any great extent. The actual selection of members for the commissions is hampered by a) lack of uniformity in the qualifications required for membership and b) lack of time for careful examination of the qualifications. The difficulty is enhanced by the fact that we have two kinds of commissions: some that have a definite task to perform, like No. 6 on astronomical telegrams or No. 38 on the exchange of astronomers, and others, whose principal purpose is to bring together persons interested in similar problems, like No. 29 on stellar spectra, No. 34 on interstellar material and galactic nebulae, or No. 36 on spectrophotometry.

Some of these criticisms were discussed at Copenhagen, but no en-

tirely satisfactory solution was found. Everyone agreed that it would be unwise to tamper with the structure of the Union unless a very much better procedure can be found. But perhaps we should seriously suggest for consideration by the Executive Committee and, later, by the General Assembly, the following items:

a) that the list of standing commissions be divided into two groups: working commissions whose members are expected to perform specific tasks, and commissions representing fields of interests (like the sections of the AAAS). The former would normally have few members; the latter would consist of all persons possessing certain qualifications.

b) that the list of working commissions be frequently revised and those commissions be dissolved whose tasks have been completed.

c) that nominations for the chairmanships and memberships of all commissions be made, as at present, by the Executive Committee, but only after preliminary nominations have been received from the national committees and by the latter from the principal institutions of each country.

d) that the Executive Committee announce a definite policy in regard to the qualifications required for membership. It is probably desirable to restrict membership to persons who are active in research and have produced results which have advanced knowledge in the field covered by a commission.

II

The opportunity to get together with many old friends from foreign lands, after so many years of war and turmoil, was indeed an unusual pleasure. Dr. Oort had arranged a small symposium on interstellar matter in which short papers were presented by himself, Lindblad, B. Strömgren, ter Haar, Minnaert, Stebbins, and Struve. A paper sent by Swings was also read. Professor Shapley presided. The meeting was attended by several physicists and astronomers, not only from Denmark, but also from Sweden. We were especially glad to see Dr. Edlén. The communications brought out very clearly, what we had noticed also in other respects, namely, the enormous progress, especially in theoretical astrophysics, which has been made during and since the war in the Netherlands and in the Scandinavian countries. For example, Oort brought out in his paper the unexpected importance of vaporization by the encounters of interstellar particles in providing the delicate balance between gas and dust clouds which we actually observe in the universe, while ter Haar, in collaboration with Kramers, elaborated on the mechanism of equilibrium of interstellar C, C^+, H, CH, and CH^+. Finally, Van de Hulst and Minnaert presented some extremely illuminating ideas concerning the scattering and diffraction of interstellar particles. In Denmark, B. Strömgren has greatly extended his own work and that of his numerous pupils on model stellar atmospheres. The beginning of

this work, but insufficiently known in the United States, was published in the Elis Strömgren anniversary volume, which arrived just before America entered the war.

In the evening of March 11 Dr. Shapley gave an inspired lecture on "Galaxies" for a large University audience at the beautiful "Aula" of the great, old University. The following day, through a mix-up in the office his name had been inadvertently omitted from Commission No. 28 on Extragalactic Nebulae. "A result, no doubt, of my lecture of last night," said Dr. Shapley! (The name was promptly restored.) Unfortunately, we could not stay for the evening lecture by Sir Harold Spencer Jones on "Halley and his Time": our reservations made it necessary for us to depart a few hours earlier.

The Observatory in Copenhagen is located on a small hill within the Botanical Gardens of the University. In front of the main building is a statue of Tycho Brahe, the 400th anniversary of whose birth will be celebrated on December 14 of this year. The little 4-year-old son, Ole, of the Bengt Strömgrens, thought it was lots of fun to throw snowballs at old Tycho. We were royally entertained at Copenhagen —perhaps the only city in Europe where food is not too scarce. Bengt Strömgren is now the director of the observatory, and is devoting part of his time to the organization of a new observatory outside the city. He and his family live in the old director's residence in one wing of the observatory building. Miss Vinter Hansen lives in the other wing. Professor and Mrs. Elis Strömgren, now retired, live in a pleasant apartment on Stockholmsgade, within easy walking distance from the observatory. For the elder Professor Strömgren the Copenhagen conference marked a high point in a long career devoted to the preservation of friendly relations between scientists of all countries. Both Strömgren families and Miss Vinter Hansen entertained the delegates at dinner. These occasions gave us a very welcome opportunity to meet some of the leading Danish scientists, such as Professor Niels Bohr, Professor Nielsen, and Professor Hansen. The latter has constructed some very fast Schmidt cameras, working at aperture ratios of less than f/1, for the kinematographic recording of X-ray pictures in medical practice. The difficulty of bending the film to the required radius of curvature was overcome by a simple mechanical device.

The trip by plane, though delayed by bad weather, was full of interesting and amusing incidents. At Shannon Airfield in Eyre, where we spent a full day, we saw Eamon de Valera. Shapley promptly took advantage of the occasion to arrange an interview, which at the time of this writing already promises to bear rich fruit in the advancement of astronomy in Ireland! The night was spent at the Blue Boar Hotel of Tipperary, where the city water main had burst just before we ar-

rived, and running water was not to be had. At Prestwick Airport, in Scotland, we spent several hours with Professor W. M. Smart who had come from Glasgow to see us. We also accidentally met Professor Klopsteg of Northwestern University who was traveling in Europe on an official mission.

From the international point of view the most significant feature was the presence of the Russian delegates. Although Russia adhered to the Union before the war, their astronomers had not taken a very active part in the work of the Union. They arrived in Copenhagen two days late, but were in time for most of the important decisions. Professor A. A. Mikhailov is well known for his work on the theory of eclipses. He is the chairman of the Russian Astronomical Council. Dr. G. A. Shajn is a member of the Russian Academy of Sciences, and has also been appointed the director of the Crimean Astrophysical Observatory —a new and independent institution which will rise on the ruins of the old Simeis branch of the Pulkovo Observatory. Mrs. P. Shajn, whose name is known to astronomers in this country for her frequent papers on stellar spectra, radial velocities, and interstellar absorption, accompanied her husband to Copenhagen, but did not attend the sessions.

The Russian astronomers are planning to rebuild the Pulkovo Observatory as a center for research in positional astronomy. The Crimean Observatory will be devoted entirely to astrophyiscs. A commission of ten of their best astronomers will visit the United States this summer in order to study our observatory installations. At the Zeiss works in Jena the Russians found some of the unfinished instruments which Hitler intended to present to Mussolini: some of these instruments will probably be finished for the Russian observatories. In addition to these relatively small instruments they are planning to order at least one large reflector—how large, will have to be determined later.

The question of personnel is very serious in Russia. Many young astronomers lost their lives in the war. Even before the war the number of competent astronomers was sadly insufficient. (But we read with surprise in a recent official communication from Russia that the pre-war staff of Pulkovo consisted of some 150 scientists!) The importance of training is fully realized, however, and a concerted effort is being made to produce first-class textbooks. I have pointed out in recent reviews in the *Astrophysical Journal* that this policy will give the Russian students a very great advantage over students in other countries. It is impossible to predict whether these efforts will really bear fruit. It is, of course, well known that not all factors operating in Russia now are necessarily beneficial to science. At the present time the Russians have neither the telescopes, nor the observational astronomers to compete with us effectively, but in a few years this difference may have disap-

peared. Even now some of their work, to mention only that of Ambarzumian in theoretical astrophysics, is unsurpassed anywhere. We must not be misled by their use of poor paper, or even by frequent misprints and the generally careless appearance of their publications, into thinking that their work is of no great consequence. On the contrary, we should regard their efforts as a symbol of potential Russian strength in science.

In conclusion, I believe that the Copenhagen conference has done much to cement friendly relations between astronomers of many lands. It has given us a better insight into the conditions of work, the problems and the obstacles with which our colleagues in Europe are confronted. In some countries, like Poland and its neighbors, the need is great. Not only astronomical publications, but food and clothing are desperately needed. In most others the astronomers ask for all the publications we can spare. I earnestly hope that every reader of this article will make an effort to send to as many European observatories as possible reprints of their scientific articles since 1940, and that observatory directors will arrange to mail their publications without delay —through the mail rather than through the Smithsonian Institution exchange bureau, in order to save time. Many observatories will require complete sets. However, such sets should not be sent until requests for them have been received. The hunger for knowledge surpasses even the very real hunger for food! There is a great demand for astronomical periodicals. Because of exchange restrictions very few observatories in Europe are now able to subscribe to the *Astrophysical Journal*, the *Astronomical Journal*, the *Publications of the Astronomical Scoiety of the Pacific, Popular Astronomy*, and *Sky and Telescope*. Since these journals operate on a budget basis few, if any, copies can be sent free of charge by the publishers. In the case of the *Ap. J.*, arrangements have been made in exceptional cases to defer payments. But this form of aid is insufficient and unsatisfactory. I wonder whether some readers of this article would like, as a personal gift to an European observatory, to enter subscriptions for one, or more, of these journals? They would not only receive the gratitude of the foreign astronomers, but would render a significant service to American science, by making its results known abroad. The European astronomers can reciprocate by sending us their observatory publications and by helping us to arrange subscriptions for their own journals. It is still very difficult to obtain the Russian journals: a few are being sent to America free of charge, but efforts to place regular subscriptions for others have sometimes failed. It has also been difficult to order books from Russia.

Much of the success of the Copenhagen conference is due to Professor Shapley. Not only was it at his meeting last year with the Astronomer Royal and with the astronomers in Russia that the idea

of the conference was proposed, but he made all the preliminary arrangements in this country, secured the necessary funds, and unstintingly gave his time and energy to the enterprise. American astronomers have good reason to be grateful to Dr. Shapley!

FOOTNOTES

[1] H. Shapley: Notes on the International Copernican Memorial Observatory, *Kosciuszko Foundation Bull.*, No. 1, 1945.

The Development of Astronomical Photometry

By HAROLD F. WEAVER

(Continued from page 299)

THE DEVELOPMENT OF THE COMPARISON METHOD: THE ESTABLISHMENT OF THE NORTH POLAR SEQUENCE

By 1910 we were in possession of a number of methods of establishing magnitude scales. Some of these were capable of producing results of high precision and have, with minor modifications, been used regularly up to the present time. But, unfortunately, during this period of growth of methods there seemed to be little general desire to standardize the photometric system in any very useful way.

Towards the end of this decade of experiments in fundamental methods the interest of some observers engaged in photometry began to shift to another procedure for determining magnitudes. It began to appear desirable to some observers to establish one fundamental standard-magnitude scale in the sky, which, by comparison, could be transferred to any other area. Such a comparison would merely involve photographing on one plate with equal exposure times and when at equal altitudes the area in which magnitudes were desired and the standard area, and no auxiliary equipment such as half-filters, gratings, and so forth would be needed. Kapteyn, Gill, and others had spoken of this process for some time. Pickering, in a paper published in 1906, mentioned briefly that the procedure had been successfully used at Harvard for a number of years and that his standard scale was located in the immediate neighborhood of the north celestial pole. In 1907 he described the method more fully, and later still, in 1909, dealt[32] with the method in detail, and proposed as a standard scale a sequence of 47 polar stars for which magnitudes were then being determined at Harvard. Plans were in progress to extend this fundamental sequence to the very faintest stars through cooperation with those observatories

[32] *H.C.O. Circular*, 150.

possessing large telescopes, and also to form secondary standard sequences in other regions through comparisons[33] with the primary standard sequence of polar stars.

At the meeting of the Astrographic Congress held in 1909 Kapteyn, then President of the Commission on Photometry, proposed that the general comparison method of establishing magnitude scales be adopted as the recommended procedure for determining the magnitudes of the *Astrographic Catalog*, and that there be established a number of standard photographic magnitude sequences in order to facilitate these comparisons. These standard sequences were to be of the nature of secondary standards since they were to be established through comparison made with a primary standard photographic magnitude sequence at the pole. Kapteyn's proposal was adopted, but the Congress was very reluctant to commit itself as to what this primary photographic magnitude scale should be. It did, however, appoint a sub-commission to investigate the problems involved in the establishment of such a standard scale, and to make recommendations as to what scale and zero point should be finally adopted. The Congress recommended to the sub-commission that the scale be independent of the then existing visual magnitude scale, and suggested, further, that Pickering's North Polar Sequence was probably the most satisfactory photographic magnitude scale then to be found.

In 1910 this sub-commission recommended that the zero point of the photographic magnitude scale to be used in the *Astrographic Catalog* be such that the mean photographic magnitudes of A0 stars between magnitudes 5.5 and 6.5 should equal the mean Harvard visual magnitudes of those stars. The scale itself was to be a Pogson Normal Scale, and the primary standard sequence was to be Pickering's North Polar Sequence. The task of setting up secondary standards in the various astrographic zones was to be undertaken at Harvard.

The problem of establishing a completely satisfactory North Polar Sequence was immediately taken up at a number of observatories.

In 1912 Pickering[34] published provisional photographic magnitudes for the chosen North Polar Sequence which, at that time, had increased in size to a group of 96 stars. At Greenwich the area covered by this original sequence was enlarged and the number of brighter stars for which magnitudes on the Harvard scale were available increased considerably for the sake of convenience in making comparisons. In addition, the scale of the standard sequence was investigated between the

[33] It is interesting to note in passing that in describing the procedure recommended for making polar comparisons Pickering suggested a simple graphical method for the reduction of the plates. This was not only a more rapid but also a much more flexible method than the mathematical formula method generally used then and previously. Pickering also warned against the color equation to be expected for different instruments.

[34] *H.C.O. Circular*, 170, 1912.

magnitude limits 9 and 16 by means of gratings. The brighter stars of the Sequence had already been observed independently in the course of other work by Parkhurst at Yerkes and Schwarzschild at Göttingen, and magnitudes determined for the brighter stars by those observers were available in 1912. In 1913 Seares at Mount Wilson investigated the homogeneity of the scale of the sequence through comparison of bright stars by means of screens and diaphragms for stars in the magnitude range 10.5 to 15.5.

In 1915 Miss Leavitt[35] summarized the work of the Harvard College Observatory on the North Polar Sequence. In establishing the magnitudes of the stars in the sequence there were used some 300 plates taken with 13 instruments ranging in aperture from ½ inch to 60 inches. Four independent means of establishing the scale had been utilized. These included: 1. The out-of-focus method making use of the inverse square law of variation of variation of intensity of light. 2. The use of two thin plates of Iceland Spar mounted directly in front of the photographic plate in such a way that they could be turned at any angle to each other. Light from any star passing through these plates was divided and formed four images of known intensity ratios. 3. The reduction of light intensity by a known amount through use of (a) wire screen in front of the objective; (b) wire screen in front of the plate; (c) screen of perforated tin in front of the objective; (d) shade glass in front of the plate; (e) an evenly exposed and developed photographic plate in front of the plate to be exposed. 4. The reduction of light intensity by a known amount through change of the size of lens aperture by (a) covering each half of the objective in turn; (b) placing a circular diaphragm over the objective; (c) using a prism of small angle in front of the objective to form for the bright stars faint prismatic companions having a known fraction of the intensity of the primary image. Methods (4c) and (2) require only one exposure for the establishment of a magnitude scale; the other methods described require two or more exposures of equal length for the establishment of a scale.

During the investigation it was found that many of the instruments used required large distance-from-center corrections, and that when successive exposures were required for the establishment of the scale, changes in focus and other conditions from one exposure to the next sometimes modified the apparent brightness of the images. Likewise, some difficulties were experienced with the variation of effective color sensitivity from one instrument to another. While all errors which could be allowed for were corrected in the final scale, it seemed desirable (to quote Miss Leavitt) "that the standard scale should be investigated further by different observers using independent methods."

[35] *H.C.O. Annals*, **71**, No. 3.

In 1914 Dziewulski[36] checked the magnitude scale of the polar standards with wire gauze screens and the 80-cm refractor at Potsdam.

A year later Seares[37] published his investigations on the absolute scale of photographic magnitudes of the Polar Sequence in the magnitude range 2.5 to 20.0, and of the photovisual scale in the magnitude range 2.0 to 17.5. By means of diaphragms and screens a scale was first established for stars of intermediate brightness and then extended in both directions. The internal accordance of the final results achieved was satisfactory, and with due allowance for color of the stars, the photographic scale agreed well with the scales established at Harvard, Greenwich, and Potsdam in the magnitude range from ten to fifteen. There was also agreement between the scales of bright stars determined at Mount Wilson and Yerkes and Göttingen, but agreement between the Mount Wilson and Harvard scales was lacking for both bright and faint stars. This lack of agreement could be traced to two factors: small residual color errors which were apparently in the intermediate magnitudes determined at Harvard, and which, through an extension of the scale, caused the brighter stars to be in error, and to improper distance-from-center corrections applied to the Mount Wilson plates used at Harvard which caused the scale of the fainter stars to be in error.

Still another determination of the photographic scale of the stars in the North Polar Sequence down to a limit of magnitude 13.4 was made at Greenwich[38] with the 13-inch astrographic refractor in conjunction with a parallel wire grating. The results obtained confirmed the Mount Wilson scale determined by Seares.

In 1922 Seares, acting in the capacity of President of the Commission on Stellar Photometry of the International Astronomical Union, presented[39] a detailed and critical analysis of all material bearing on the photographic and photovisual magnitude scales, of the North Polar Sequence. For a discussion of the photographic scale nine series of measurements were available. In preparing these series for combination, the results obtained with the 60-inch reflector and the 10-inch photographic refractor at Mount Wilson were first united to form a provisional magnitude scale. This first provisional scale was then combined with the Greenwich results mentioned above (the zero point and color system were the same as those of Mount Wilson) to form a second provisional system. Each of the scales to be combined with this second provisional system was then discussed for zero-point error, scale error, and color error. Thus each system was converted to the provisional system through an equation of the general form

[36] *A.N.*, **198**, 65, 1914.
[37] *Ap. J.*, **41**, 249, 1915; *Mt. W. Cont.*, No. 97.
[38] *M. N.*, **82**, 21, 1921.
[39] *Trans. I.A.U.*, Vol. I, 1922, p. 69.

$$m_p = a_o + a_s m + a_c C$$

where m_p is the magnitude of a given star on the provisional system,

a_o is a constant, the zero-point error of the scale being discussed,

a_s is a constant, the scale factor of the scale being discussed,

m is the magnitude of the given star on the scale being discussed,

a_c is a constant, the color coefficient of the scale being discussed,

C is the color of the star on the provisional system.

If, in addition to the usual systematic differences enumerated above, there is present in any magnitude series Purkinje (or Gallisot) effect, as there often is for visual magnitudes, the coefficient a_c is not a constant as described, but becomes a function of m, which, experience has taught us, may, in general, be represented by an equation of the form

$$a_c = \alpha_c + \alpha_m m$$

where α_c and α_m are constants.[40] In the scales discussed by Seares it was unnecessary to consider a_c as a function of m, and in only one instance did a_s differ from unity. Hence, for Seares' discussion the actual equation used had the simplified form

$$m_p = a_o + m + a_c C.$$

The results obtained by means of this equation were quite satisfactory. The seven independent scale determinations available from the nine series were in substantial agreement, but there were slight discrepancies in the zero points of the various series, which, at the time, were not of sufficient size to cause alarm. The zero point satisfied (so far as was known at that time) the international definition in regard to equivalence between visual and photographic magnitudes of A0 stars in the magnitude range 5.5-6.5. It was realized, however, that the number of available early-type stars near the sixth magnitude was so small that the zero-point determination, might not agree exactly with other determinations made in other parts of the sky.

The accidental errors of the magnitude determinations were satisfactorily small, the weighted mean deviation of a single star being as follows for the several series:

Göttingen	0^m038	Harvard (I)	0^m019
Greenwich (26 inches)	0^m028	Harvard (II)	0^m029
Greenwich (13 inches)	0^m025	Mount Wilson (60 inches)	0^m022
		Mount Wilson (10 inches)	0^m025
		Potsdam	0^m041
		Yerkes	0^m047

The photovisual scale established by Seares and presented at the 1922

[40] In the most general case, probably a_o, a_s, and a_c might all be functions of m and C. Experience shows, however, that the simple equation with constant coefficients is generally sufficient.

meetings of the International Astronomical Union rested upon many fewer observations than the photographic scale, and was, in fact, determined from observations made only at Mount Wilson. The Harvard visual magnitudes, when reduced to the Mount Wilson color system, showed scale agreement at magnitudes 6 and 12, but between these values there existed a scale error of appreciable size. The peculiar type of scale disagreement exhibited, it was discovered later, was caused by the fact that each of the three meridian photometers used in the measurement, was used in a different magnitude interval, and the scales of the photometers were not identical. Visual and photovisual scales from other observatories, while examined, were of too limited extent to be of value and were not included in the reductions.

Thus, in 1922, standard scales of magnitudes accepted by astronomers by international agreement were at last available. These standards have now served as examples of photographic and photovisual magnitudes, fixed the zero points of both scales, and defined a reference system for colors of stars for nearly a quarter century. Several small photometric discrepancies have been discovered in them during this time, and, unfortunately, in some respects the sequence has proved to be inadequate.

It was found rather early that the convention of the International Zero Point was not completely satisfied. Owing to the small number of stars available in the brightness range from which the zero point had to be established, the zero point was in fact determined in such a way that on the scale of the North Polar Sequence an A0 star has a color index of —0.04 magnitude instead of zero. Recently, moreover, Seares and Stebbins have found that a thin layer of interstellar absorbing material lies over the north celestial pole, hence color indices of A0 stars unaffected by selective absorption of light determined by comparison with the North Polar Sequence average about —0.15 magnitude. Tests of the scale made through photoelectric measurements indicate that there may be some irregularities in the scale of the very brightest stars and that these may require further investigation. A very recent investigation of the colors of the stars of the North Polar Sequence indicates that very small discrepancies in the scales exist at least over the brighter halves of the scales, but the apportionment of the error between the two scales is uncertain.

"Attempts to transfer the photometric system of the North Polar Sequence to other parts of the sky," to quote Seares,[41] "have met with serious difficulty. The standards are few and scattered, B-type stars are lacking, and the red stars do not accurately define the color system. As a group, these standards can be observed only with large-field cameras which require complicated corrections depending on color, brightness, position of the stars, and frequently also on focus and other

[41] Seares, Ross, and Joyner, "Magnitudes and Colors of Stars North of + 80°," Carnegie Inst. of Wash., 1941, p. 1.

factors such that each plate must be treated by itself. The bright polar standards thus failed of the purpose for which they were intended." This failure through lack of numbers has been remedied by the appearance of the excellent polar catalog of 2271 stars by Seares, Ross, and Joyner from which the above quotation was taken. Unfortunately, however, the question of the final accuracy of the scales has still to be settled.

But if complaints could be made about the bright stars of the North Polar Sequence likewise complaints could be made about the faint stars. With large instruments the establishment of a scale of magnitudes by polar comparison is very difficult. The pole is poorly located, for most observatories it is unnecessarily low in the sky; it is generally too far away from the area being observed and differences in seeing owing to great change of azimuth are likely; guiding at the pole is likely to be done differently from that at another region in the sky. All these factors are of great importance in causing systematic errors in scales established with large telescopes. Some of the troubles encountered with the bright stars are also encountered with the faint stars; "blue stars are lacking and the red stars do not accurately define the color system." For the faintest stars the standard values depend on only a few Mount Wilson observations and should be rechecked by further work. Because of these difficulties it seems likely that in the future the North Polar Sequence of faint stars will have to be supplemented by several series of standards more conveniently located.

Photometric Catalogs in the Modern Period

Activity in the field of photometry following the first decade of the modern period was not confined to work on the Polar Sequence as might be inferred from the rather detailed description of its growth which has been given. Starting in 1910, the publication of photometric catalogs began to take place at an ever increasing rate. Even to list the published photometric catalogs would require an undue amount of space; only a few can be mentioned briefly.

In 1910 and 1912 were published the two volumes of the *Göttingen Aktinometrie* of about 3500 *B.D.* stars complete to magnitude 7.5 in the zone 0° to +20° declination. The observations for this catalog, the first accurate photographic catalog, were made with a shraffierkassette. The scale, established from exposures of different lengths by a method devised by Schwarzschild, was carefully made homogeneous by means of overlapping plates, and was corrected for all types of systematic errors. Originally arbitrary, the scale was reduced to a Normal Pogson Scale by means of exposures taken with a grating, and finally adjusted for zero point.

In 1912 Parkhurst published the *Yerkes Actinometry* which contains photographic and photovisual magnitudes for stars brighter than mag-

nitude 7.5 in the declination zone +73° to +90°. These magnitudes were determined from extra-focal images; the scale was established by means of sensitometer spots of known intensity ratios, and adjusted to the International Zero Point.

The Harvard Standard Regions, which were formed in 1884 by dividing the entire sky up into 48 convenient equal areas, and which have served as sampling areas for statistical studies, are, because of the convenient locations of their centers which are spaced along the parallels of declination ±75°, ±45°, and ±15°, suitable areas for secondary standards of magnitudes. In 1911, but more especially in 1917 and during the succeeding years, standard sequences of various types were established in these areas by various Harvard observers, generally, by means of polar comparisons.

In 1919 sequences for standardization of the photometry of the *Astrographic Catalog* were published by Harvard for the northern hemisphere; in 1924 and 1926 similar sequences were published for the southern hemisphere. These, too, were secondary standards formed by comparison, in part, at least, with the primary standards at the north pole.

The Kapteyn Selected Areas received a considerable amount of attention, and a number of photometric catalogs cover these fields. In 1918 the first of the volumes of the *Harvard-Groningen Durchmusterung* was published. This contained positions and photographic magnitudes[42] determined by polar comparisons for 115 Selected Areas between 0° and +90° declination. The volumes containing positions and photographic magnitudes[43] for stars in the southern hemisphere appeared in 1923 and 1924. In all some 250,000 stars are listed in these catalogs. At Yerkes, Greenwich, and Potsdam there were undertaken surveys of the brighter stars over larger fields of the Selected Areas. In 1930 the extensive *Mount Wilson Catalog of Selected Areas 1-139* was issued. The scale of this catalog, which gives positions and photographic magnitudes of nearly 70,000 stars to an average magnitude limit of 18.5, was set up by the same methods employed in Seares' studies of the Polar Sequence. Zero points were adjusted by means of Polar comparisons and systematic intercomparisons of the various regions.

A South Polar Sequence was established; the Cape Zone Catalog of more than 20,000 stellar magnitudes of stars in the zone of declination —40° to —52° was published; sequences in the Magellanic Clouds were observed; an extension of the *Yerkes Actinometry* came out; photometric catalogs of stars at the north celestial pole and the north galactic pole were prepared. Indeed, so many catalogs of photographic and photovisual magnitudes of extended regions and special regions

[42] Limiting magnitude 16.1.
[43] Limiting magnitude 16.4.

have appeared that it is not possible to give even a fragmentary list of them.

The Increase of Knowledge of the Photographic Process in General

And as photography began to be more and more generally used in all branches of science after 1900, our knowledge of the photographic process and of the behavior of photographic plates has constantly increased. Much of this knowledge is of a theoretical nature and not of immediate application to the problems of photometry; all of it is, however, of importance as background material. Among the discoveries of more immediate application to photographic photometry should be mentioned the extension and amplification of the law of Schwarzschild by E. Kron[44] in 1913, and its use in astronomical photometry by Halm; the intermittency effect, known as early as 1893, but studied from the point of view of sensitometry in 1914 by Weber, in 1916 by Howe, and others; the effects of various developers; the change of plate gradation with wave length; pre- and post-exposure effects; the effect of emulsion thickness on characteristic curves; and the effects of image contraction.

Other notable advances following the first decade of the modern period have been made in the development of new photometric measuring devices, in improvements in the methods of establishing magnitude scales, and in the use of special plate-filter combinations to set up sequences for specific chosen wave-length ranges.

The Introduction of Physical Photometers for Measuring Photographic Plates

The desirability of making use of purely physical methods for the determination of stellar magnitudes from photographic star images was strongly felt by some astronomers during the early modern period, and was emphasized on several occasions[45] by Pickering in connection with the photometric work at Harvard. During the years 1911-1916 H. T. Stetson[46] devised such an instrument for measuring stellar images which worked on a very simple principle: the energy absorbed from a beam of light by the silver grains in the stellar image on a photographic plate was measured, and was subsequently interpreted in terms of stellar magnitude.

A few years later, J. Schilt[47] at Groningen independently constructed an instrument very similar to that finally perfected by Stetson and of

[44] *Publ. des Astroph. Obs. zu Potsdam*, No. 67, 1912; H. S. Jones and J. Halm, *Trans I.A.U.*, Vol. II, 88, 1928.

[45] *H.C.O. Circulars*, No. 155; *H.C.O. Annals*, **71**, No. 5.

[46] *Pop. Astr.*, **23**, 23, 1914; *Ap. J.*, **43**, 253, 325, 1916.

[47] *B.A.N.*, **1**, 51, 1922; *Gron. Astron. Lab. Pub.*, No. 32, 1924; *B.A.N.*, **2**, 135, 1924.

almost precisely the form which is generally used for such photometers today. A pencil of light from a constant voltage lamp is condensed by a microscope objective into a small luminous spot on a photographic plate. The size of this spot, which can be controlled by changing a diaphragm in the condensing system, and which is constant during the measurement of any one plate, is chosen as small as possible consistent with the sizes of the star images to be meaured and the sensitivity of the apparatus. The beam of light, after passing through the plate, is projected onto the receiver of a thermopile (or onto a photocell) by means of a second microscope objective, and the current generated through absorption of the energy in the light beam by the thermopile (or photocell) is measured by the deflection of a galvanometer. The photographic plate is mounted in the focal plane of the first microscope objective on a carriage having motion in two coordinates and thus any desired star image can be centered in the beam of light for measurement.

Measurements with such a photometer are made very simply and consist of a determination of the galvanometer deflections for the star when centered in the beam, and for the fog background in the immediate vicinity of the star image. The theory and practice of transforming these deflections into magnitudes as well as errors to be avoided in making the measurements have been discussed by Seares[48] and by Ross.[49]

A modification of this general type of photometer proposed by H. Seidentopf[50] in 1934 appears to offer certain advantages in some respects over the original Stetson or Schilt type and would seem to repay further study. Essentially, the modification changes the photometer to a null type instrument which measures effective image diameters. This is accomplished by substituting for the diaphragm of fixed size which determines the diameter of the spot of light on the plate an iris diaphragm of variable aperture. Measurement of a plate with this instrument is accomplished (1) by centering the stars, one by one, in the beam of light and determining the diameter of diaphragm aperture necessary to produce a prescribed galvanometer deflection, and (2) by determining the diameter of diaphragm aperture necessary for the fog background of the plate in the immediate vicinity of each star image to produce the same prescribed galvanometer deflection. The primary advantage of the instrument is that the reduction curves connecting final effective diameter (fog density being taken into account) and magnitude are nearly straight lines over a much longer range than they are with the ordinary photometer.

[48] Seares, Ross, and Joyner, "Magnitudes and Colors of Stars North of + 80°," Carnegie Inst. of Wash., 1941, p. 10.
[49] *Ap. J.*, **84**, 241, 1936.
[50] *A. N.*, **254**, 33, 1934.

Recent Advances in Establishing and Transferring Scales

Among the various suggestions for modifying old methods, and proposals for using new methods for establishing or transferring magnitude scales, there are two relatively recent proposals which are of considerable interest and merit detailed discussions. The first of these deals with the establishment of a magnitude scale by means of a neutral half-filter in the general manner suggested originally by Schwarzschild and Kapteyn; the second is an improved procedure for transferring a magnitude sequence through comparison.

With the perfection of methods of depositing thin films of metal on glass through evaporation or sputtering of the metal in vacuum, it has become possible to make filters of a high degree of neutrality and with almost any desired absorption constant. From experiences at Göttingen, Leipzig, Mount Wilson, and elsewhere it appears that platinum half-filters[51] can be used to establish highly accurate intensity or magnitude

The constantly increasing use of these neutral half-filters in a manner similar to that suggested by Kapteyn in his half-filter method represents a further important forward step in photometry inasmuch as it points to the growing realization of many observers that an accurate magnitude scale cannot be established by means of two exposures taken at different times. Even over a relatively short period of time the observing conditions (primarily the seeing) can, and frequently do, change sufficiently to vitiate the assumption of constancy of conditions during the two exposures. In the half-filter method a scale is established from each exposure. Inasmuch as two exposures are taken on each plate (the half-filter is rotated through 180° between these exposures it will be recalled), each half-filter plate yields two independently determined magnitude scales.[52]

Unfortunately, there is one important objection to the half-filter method; the sky fog does not build up in the same manner for the two

[51] Platinum half-filters so far constructed have not been perfect inasmuch as they are not completely neutral over the entire usable wave-length range (see H. Kienle and H. Siedentopf, *Z.f. Phys.*, **58**, 726, 1929; H. Kienle, *Z.f. Ap.*, **1**, 13, 1930; **4**, 282, 1932; H. Kienle in *Hb. d. Exp. Phys.*, **26**, 768, 1937), and are sometimes not uniform in absorption over the entire usable area of the filter. The degree of neutrality of a platinum filter is a function of its density. Those filters having an absorption constant of about one magnitude are more nearly neutral than those having larger or smaller constants. It is probable that in the future it will be possible to achieve a more satisfactory degree of neutrality through the use of some metal other than platinum in the construction of the filter.

The slight variation in the absorption constant from one part of the filter to another is caused by irregularities in the thickness of the platinum film. This difficulty can be eliminated from future filters by proper placement of the sources from which the platinum is evaporated.

In spite of these difficulties, the scales that have been established with the aid of the half-filters now available are among the most accurate scales in existence.

[52] The method of reducing these plates and obtaining these scales is quite direct, but is rather too involved to discuss in this historical review.

filter exposures. For one exposure there is pre-fogging, for the other post-fogging. The effects of this difference in fogging may be minimized by taking at least two filter plates (determining four independent scales) in opposite order; that is, taking the first plate in the order filter east, filter west; and the second plate, filter west, filter east, and by choosing for this work plates which are as free as possible from fog effects. Experience seems to indicate that by careful attention to these details the fog objection can be overcome. It may be possible to eliminate the effects of fog in the reduction procedure, but studies made so far indicate that the procedure to accomplish this with complete satisfaction will be somewhat complicated.

In the transfer of a magnitude scale from one area of the sky to another through photographic comparisons, there are present a number of sources of systematic error. The most common causes of such error are changes in seeing, guiding, or focus from one exposure to the next. Generally speaking, the larger the telescope employed, the more sensitive the magnitude scale is to these changes. In transferring scales through comparison by means of the 60-inch reflector at Mount Wilson, for example, systematic errors as large as 0.5 magnitude are occasionally encountered, and even for plates taken on apparently excellent nights systematic errors of 0.2 magnitude are not uncommon.

The effect of changes in the observing conditions is such that as the seeing, guiding, or focus becomes poorer, the bright stars apparently become brighter and the faint stars apparently fainter. If the bright stars appear brighter and the fainter stars fainter, there must be some point of optimum density, some group of stars of intermediate brightness, which is not affected by these changes in observing conditions. The existence of such a point of optimum density has been noted by A. Blaauw,[53] and he has made use of it in a method of reduction which requires two comparisons (of different exposure times) of the same field, and which statistically eliminates the systematic errors arising from changes in the observing conditions. Actually, the existence of this point of optimum density has been recognized and used by Trumpler[54] for many years, and has also previously been mentioned by Zug.[55] The general method of reduction proposed by Blaauw is capable of great generalization, and in its generalized form is recommended for use in the reduction of all photometric comparison plates taken with large instruments.[56]

The Establishment of Red Magnitudes

The use of orthochromatic plates in combination with suitable yellow

[53] *B.A.N.*, **9**, 141, 1940.
[54] *L.O.B.*, **18**, 176, 1938.
[55] *L.O.B.*, **16**, 121, 1933.
[56] An account of the generalized Blaauw method will be published in the very near future.

filters has already been mentioned as a means of determining photovisual magnitudes. Experiments carried on in 1902, and more particularly in the period 1906-1919 and later, have provided new optical sensitizers[57] which permitted work beyond the orthochromatic green region in the orange, red, and infrared regions of the spectrum. As practical plates for these spectral regions became available, astronomers began to make use of them in opening new fields of photometry. In 1924 King, and later in 1930 King and Ingalls, determined[58] red magnitudes for 37 stars through use of King's extra-focal method. Shortly thereafter in 1933-1934 F. Becker at Potsdam made use of more suitable plates and determined red magnitudes with an effective wave length of 7100 A for 190 stars. Similar work in the red region of the spectrum has been carried on by Collmann at Bonn (1934). Further, Mrs. Gaposchkin at Harvard has established sequences of red magnitudes in the various Harvard Standard Regions and at the North Pole, to serve as preliminary standards. The effective wave length of these Harvard red magnitudes is approximately 6300 A (Eastman 1-C plates were used in conjunction with a cine red filter); the scale was established by means of an objective grating; the zero point was set by a method involving ordinary and red color indices.[59]

Since the original work started in 1924 and 1930, observers at Harvard and elsewhere have continued to explore photometry of the near red region of the spectrum with interesting and useful results. The field promises to be a very important one in the future.

Approximate magnitude scales have also been established in the infrared region of the spectrum (effective wave length 8500 A) by Hetzler.[60] Indications are that photometric work in this interesting region is entirely feasible.

[57] Eder, "History of Photography" (Columbia, 1945), p. 473.
[58] *H.C.O. Annals*, **85**, No. 11, 1940.
[59] *Pub. A.A.S.*, **8**, 46, 1934; *H.C.O. Annals*, **89**, No. 5, No. 9.
[60] *Ap. J.*, **83**, 372, 1936; **86**, 509, 1937. Some work was also carried on at λ 9500.

(To be continued)

American Observations of Relative Sunspot-Numbers in 1945 for Application to Ionospheric Predictions

By A. H. SHAPLEY

Introduction—The association of average ionospheric characteristics and average solar activity has been recognized for ten or more years. On the basis of the accumulated ionospheric data through a complete 11-year solar cycle at Washington, D. C., Huancayo, Peru, and Wath-

eroo, Western Australia (and for a shorter period at other locations) the Interservice Radio Propagation Laboratory (IRPL) has summarized in nomographic form the relationship between mean sunspot-number and *F2*-layer ion-densities at various geographic latitudes, for use in making long-range, world-wide predictions of usable radio frequencies [see 1 of "References" at end of paper]. Current predictions require current estimates of solar activity which during the war were necessarily based on observations made in this country; during 1945 these observations were principally those made by the Solar Division of the American Association of Variable Star Observers (AAVSO) and were reduced at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington (DTM CIW).

The longest series of sunspot-number observations is that started in 1849 by Wolf at Zürich and continued by Wolfer, Brunner, and (since October, 1945) by Waldmeier. By examination of older records, Wolf and Wolfer have extended the series back to 1749.[2] The current Zürich reports are published in preliminary form in the *Journal of Terrestrial Magnetism and Atmospheric Electricity* and in the *Monthly Weather Review*. A final report of Zürich observations, supplemented when necessary by data from other observers, is issued annually in the *Astronomische Mitteilungen*. The preliminary monthly reports are received in Washington individually, normally about four weeks after the end of the month.

For the application to ionospheric predictions, an estimate of mean solar activity about four months in advance is required. This estimate is based upon predictions for the complete cycle[3] and by extrapolation of the trend of activity from current observations. During the war when the receipt of Zürich sunspot-reports was necessarily delayed by many months, sunspot-data from two and later four American observers were used to give an indication of the trend of solar activity from month to month. With the cooperation of the Solar Division of AAVSO, the number increased to 20 or 30, and beginning with December, 1944, a monthly summary of the various reports has been compiled and issued by DTM CIW. The primary purpose of the summary has been not to supplant the Zürich statistics, but to give a good, up-to-date estimate of current solar activity measured by sunspot-numbers for application to long-range ionospheric predictions.

Observers—The American sunspot-data have been provided gratuitously by some 40 solar observers, both amateur and professional. All but four send their reports as members of the Solar Division of AAVSO, through its Chairman, Neal J. Heines. The Mount Wilson Observatory, the United States Naval Observatory, and the Climax Station of the Harvard College Observatory make their sunspot data avail-

TABLE 1

EQUIPMENT AND SCHEDULE OF REPORTS OF AMERICAN SUNSPOT-NUMBER OBSERVERS, 1945

Observer	Location	Telescope inches[3]		Method[4]	Months Reported, 1945
Allen, Miss L. B.	Frederick, Md.	8	r	p	Jan.-Mar.
Bartlett, J. C., Jr.	Baltimore, Md.	3	r	s	Jun.-Nov.
Becroft, S. W., Jr.	Yalesville, Conn.	6	R	s	Mar.-Dec.
Boulting, D. H.	Oakland, Calif.	6	R	p	Jul., Aug.; Oct.-Dec.
Brugh, J. E.	Pittsburgh, Penna.	6	R	s	Jun.-Sep.
Buckstaff, R. N.	Oshkosh, Wis.	5	r	s	May-Dec.
Chase, H. B.	Quincy, Mass.	3	r	p	Sep., Oct., Dec.
Clayton, H. H.	Canton, Mass.	4	r	p	Jan.-Dec.
Climax (Harvard)	Climax, Colo.	6	r	p	Aug.-Dec.
Cragg, T. A.	Los Angeles, Calif.	4	R	s	Jan.-Dec.
Estremadoyro, V. A.	Lima, Peru	2	r	p	Dec.
Fernald, C. F.	Wilton, Maine	8	r	s	Jan.-Dec.
Fogus, C. A.	Sacramento, Calif.	8	R	b	Feb.-Dec.
Gamble, C. H.	Moline, Ill.	5½	r	s	Jan.-Nov.
Garneau, DeLisle	Montreal, Canada[1]	6	r[5]	b	Jan.-Dec.
Haines Sci. Instr. Co.	Englewood, N. J.	20	R	p	Feb., Mar.
Harrell, B. L.	Gadsden, Ala.	4½	R	s	Feb.-Dec.
Heines, N. J.	Paterson, N. J.	3	r	s	Jan.-Dec.
Lee, Knox	Marshall, Texas	6	R[5]	b	Jan.-Mar.; May-Aug.
Liller, William	Cambridge, Mass.[2]	8	r	b	Jan.-Apr.
McCroskey, L. F.	Portland, Ore.	3	r	b	Jan.-Sep.
Mono Observatory	Coleville, Calif.	2½	r	s	Feb.-Dec.
Mt. Holyoke College	So. Hadley, Mass.	8	r	p	Jan.-Dec.
Mt. Wilson Obs.	Pasadena, Calif.	12	r	p	Jan.-Dec.
Parmenter, B. C.	Seattle, Wash.	6	R[5]	b	Jun.-Dec.
Pettit, Miss Helen	Oakland, Calif.	8	r[5]	p	Feb.-Dec.
Pinckney, C. C.	Birmingham, Ala.	3	r[5]	b	Jan.-Dec.
Power, Henry	Palo Alto, Calif.	8	R	p	Jan.-Mar.
Roemer, Miss E.	Alameda, Calif.	3	r	p	Jul.-Dec.
Rosebrugh, D. W.	Waterbury, Conn.	4	r	s	Jan.-Dec.
Rowland, E. L., Jr.	Jacksonville, Fla.	2	r[5]	b	Feb., Mar.
Rumrill, H. B.	Berwyn, Penna.	4	r[5]	b	Jan.-Dec.
Ryerson, K. A.	Davis, Calif.	4	r	s	Feb.-Jul.; Sep.-Dec.
Savedoff, M. P.	Cambridge, Mass.	8	r	s	Nov.
Saxon, P. A.	Miami, Fla.	6	R	p	Jun.-Dec.
Smith College	Northampton, Mass.	6	r	p	Sep.-Dec.
Stowe, Bruce	Bronxville, N. Y.	6	R	p	Jan.-Jun.
	Pasadena, Calif.	4	R	p	Jul.-Dec.
Stryker, K.	Lambertville, N. J.	6	R	s	Jul.-Dec.
Telford, W. S.	Sarasota, Fla.	8	R	p	Jan.-Dec.
Thorpe, S. F.	Louisville, Ky.	10	R	b	Jan.-Dec.
Topham, Bert	Ontario, Canada	6½	r	b	Jun.-Dec.
U.S. Naval Obs.	Washington, D. C.	4½	r	[6]	Jan.-Dec.
Williams, R. L.	Greene, N. Y.	3	r	s	Jan.-Dec.
Wilson College	Chambersburg, Pa.	4	r	b	Jan.-Apr.; Sep.-Dec.

*The McMath-Hulbert Observatory of the University of Michigan also supplies its solar data for the coordinated program under the Wave Propagation Committee of the Joint Communications Board.

[1] Collaborated with C. M. Good, Feb., Mar., Jul.; with F. P. Morgan, Dec.

[2] Collaborated with J. L. Gossner, Jan., Feb., Mar.

[3] R = reflector, r = refractor.

[4] p = projection, s = direct, b = both.

[5] Principal telescope.

[6] Photography.

able as one phase of the coordinated solar program.* These reports are reduced to daily sunspot-numbers at DTM CIW. The Mount Holyoke College reports are received directly.

The various contributors, their location, telescopic equipment and method of observation, and the months during 1945 in which they forwarded reports are listed in Table 1. Many of the reports were the combined efforts of several observers, and it has not always been possible to give individual credit.

Observatory constants—While the scale of sunspot-numbers is entirely arbitrary—as is the very nature of this measure of solar activity—the utility of any compilation of sunspot-number observations depends on retaining a consistent scale from one cycle of activity to the next. The Zürich series of observations has been used in almost all long-term investigations of terrestrial phenomena with relation to sunspot-numbers, and so it is almost requisite that a compilation, which anticipates the Zürich reports, should adhere as nearly as possible to the same scale. The sunspot-number was defined by Wolf as

$$r = k\,(10g + f),$$

where g is the number of sunspot groups and f the number of individual spots observed on any day. Its actual value is largely dependent on the value selected for k, the constant for observer, equipment, and average seeing conditions. The standard observer for the Zürich series is Wolf, for whose observations $k = 1$. Wolfer's constant was determined as 0.60 from a series which overlapped Wolf's by 16 years.[4] Brunner followed Wolfer's criteria for counting sunspots and continued the same constant,[5] as also, apparently, Waldmeier. The constant for any other observer may be determined by day-to-day comparison with the Zürich data.

The details of deriving a constant for any observer O comprise taking the sums of the daily numbers reported by the standard and by O, using only the days on which both made observations. The ratio of the sums, that is of the standard to O, is the constant for reduction of the data of O to the standard scale. Zürich, in deriving the constants reported annually in the *Astronomische Mitteilungen,* apparently omits days when one of the observers reports a sunspot-number of zero. This practice has not been followed in deriving the constants included in this paper.

The American reductions are issued before the receipt of the Zürich observations for the current month. In order to preserve the scale, however, Zürich is retained as the standard observer, and an experienced American observer has been designated as the secondary standard. A constant for the secondary standard observer is estimated monthly by comparison with earlier Zürich observations, and his daily observations

for the current month, corrected by this factor, become the basis for deriving the constants for the other observers. While constants for individual months are determined in this way, four-month mean constants are used to reduce current observations.

The estimation of the constant for the secondary standard observer is the most critical step. At the present time this constant for a month, n, is the average constant of the secondary standard observer, A, with respect to Zürich, Z, for the previous four months adjusted by comparison of the observations in the current month of A and a tertiary standard observer, B, as shown by formula (1).

$$\text{Est.}\left(\frac{Z}{A}\right)_n = \frac{1}{2}\left[\frac{1}{4}\sum_{n-1}^{n-4}\left(\frac{Z}{A}\right) + \left(\frac{B}{A}\right)_n \frac{1}{4}\sum_{n-1}^{n-4}\left(\frac{Z}{B}\right)\right] \qquad \text{- - -(1)}$$

Each ratio is computed from the data of days of observation common to the two observers included in the ratio. Any large change in the consistency of observer A, during the current month, is tempered by the second term in the formula, that is, the product of the mean constant for observer B referred to Zürich for the preceding four months and the ratio of B's observations to A's during the month, n. This method has been used since March, 1945, with Heines as the secondary standard observer and Mt. Holyoke as the tertiary standard. Prior to March, the mean constant for Heines for 1943 was used to correct his observations and establish them as the secondary standard.

The procedure followed in the monthly reductions is as follows: (*a*) Estimate the observatory constant for Heines, the secondary standard observer; (*b*) correct his observations for the current month by this factor; (*c*) determine constants for the current month for all other observers by comparing days common to observer and Heines, using the corrected Heines observations; (*d*) obtain for each observer a mean constant using the value derived in (*c*) and the values for the preceding three months; and (*e*) correct each observer's daily observations by the mean constant. The corrected daily values and mean constant for each observer appear in the monthly summary. If, when the Zürich data arrive, it is found that the estimated Heines constant was in error, a factor which will correct for the error is applied to the observatory constants derived for each observer; the corrected constants, if available, are used in arriving at the mean constant for each observer—step (*d*) above.

Observatory constants, even when derived from a comparison of two experienced observers, do not remain the same from month to month. The variation is attributable (*a*) to abnormal seeing conditions during a given month, (*b*) in lesser degree to the differences in times of observations of the two observers and hence actual differences in observed sunspot-activity, and (*c*) to deviations in the personal equation. Neither

of two experienced observers can be said to report the more nearly true state of sunspot-activity. Figure 1 represents the variations of the

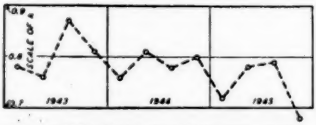

FIG. 1—OBSERVATORY CONSTANT FOR HEINES REFERRED TO ZÜRICH, BY QUARTERS, 1943-45

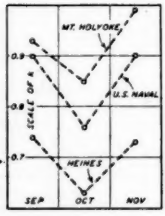

FIG. 2—VARIATION IN OBSERVATORY CONSTANTS FOR MT. HOLYOKE, U.S. NAVAL OBSERVATORY, AND HEINES REFERRED TO ZÜRICH, SEP-NOV, 1945

quarterly observatory constant with respect to Zürich of Heines, an observer with 15 years' experience. The variation shown represents the combined variations in the consistency of the two observers. The effect of a deviation in the consistency of the standard observer is shown by Figure 2, which gives the observatory constants for Heines, Mount Holyoke, United States Naval Observatory, each with respect to Zürich, for September, October, and November, 1945. The fact that all constants were lower in October than in adjacent months shows that Zürich counted a lower sunspot-number than was the usual practice there. The consistency of the scale of sunspot-numbers depends on the standard observer changing his scheme more infrequently than others.

Monthly summaries—Observations are received soon after the end of each month, and the reductions are completed and the monthly summaries issued usually between the 15th and 20th of the following month. The summary for September, 1945, given in Table 2, is an example of the form used. The mean constant used to correct each observer's daily observation is given after the name of the observer, followed by the corrected sunspot-number for each day an observation was reported. The average sunspot-number for each observer and the number of days represented are also shown. The consensus of the various observers is obtained by deriving median values for every day. The monthly number on the basis of all observations is the average of the daily median values. It may be seen that individual monthly means vary over a wide range because, among other reasons, few observers are able to make observations every day in the month.

In the summary the observers are divided into two sections, the second containing new observers and observers whose constants are not stable. The consistency of an observer has usually been evaluated from a consideration of the mean deviation of his mean constant for a given month; if the mean deviation is larger than 0.16—an arbitrarily selected value—the observer will usually be put in the second group. Median values are extracted both for the first group and for all observers.

TABLE 2

--Typical summary of relative sunspot-number observations by American observers for September 1945, issued by Department of Terrestrial Magnetism, Carnegie Institution of Washington

No.	Observer	k[b]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	[a]Heines	0.75	45	27	20	9	30	35	52	44	46	46	9	13	14	12	d
2	U. S. Naval	0.92	40	32	11	10	35	47	41	38	d	42	36	23	17	13	12
3	[c]Mt. Wilson	0.86	41	27	36	13	34	44	35	33	35	39	22	34	24	19	20
4	Mt. Holyoke	1.04	d	d	d	d	d	d	d	d	55	d	d	12	16	d	d
5	[a]Rosebrugh	0.85	36	d	42	20	26	33	d	37	52	d	d	30	14	d	0
6	[a]Rumrill	1.34	46	32	34	17	32	54	55	40	35	35	17	17	19	0	0
7	[a]Fernald	1.34	d	29	32	16	39	40	38	39	d	d	d	15	16	d	d
8	[a]Stowe	1.29	46	28	28	14	32	34	50	d	50	30	15	14	0	0	0
9	[a]Thorpe	1.02	50	40	49	26	28	28	45	d	54	53	27	13	12	d	d
10	[a]Garneau	1.63	36	36	36	18	41	42	59	41	42	20	20	d	0	d	0
11	[a]Topham	0.70	34	23	27	9	21	34	34	d	d	d	10	8	8	d	0
12	[a]McCroskey	1.10	12	16	d	d	d	31	55	47	44	44	13	13	15	0	0
13	[a]Williams	1.18	d	39	28	14	34	37	54	52	48	51	30	14	18	d	0
14	[a]H. Pettit	1.30	70	43	d	14	d	48	64	51	d	d	16	14	17	0	0
15	[a]Clayton	1.45	0	d	33	17	35	52	39	41	36	16	0	0	0	0	0
16	[a]L. Slocum	1.75	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d
17	[a]Ryerson	0.98	d	27	d	11	d	d	59	55	53	24	d	11	d	d	0
18	[a]Mono Obs.	0.77	47	29	d	10	32	37	46	52	51	51	21	22	12	0	0
Median 1-18		....	41	29	32	14	32	37	50	41	48	40	17	14	14	0	0
19	[a]Bartlett	1.84	0	d	20	20	66	d	d	d	d	d	d	d	d	d	d
20	[a]Harrell	1.58	d	d	d	d	d	d	d	43	62	17	d	17	0	0	0
21	[a]Saxon	1.76	d	d	d	d	58	44	44	44	44	0	0	19	0	d	d
22	[a]Pinckney	1.19	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d
23	[a]Telford	3.62	0	0	40	40	43	d	40	40	40	0	0	0	0	0	d
24	[a]Stryker	1.09	64	d	24	13	35	45	38	d	52	62	26	28	17	0	d
25	[a]Gamble	1.81	22	d	d	20	24	22	d	d	d	d	22	d	d	d	d
26	[a]Buckstaff	0.88	d	34	d	11	25	27	d	27	35	66	d	11	16	d	0
27	[a]Roemer	1.29	59	28	43	14	37	36	53	35	36	31	15	15	17	d	0
28	[a]Parmenter	1.90	44	44	d	d	99	99	99	55	55	23	23	21	0	d	d
29	[a]Becroft	1.34	d	d	29	15	32	35	52	d	d	d	d	17	15	d	d
Median 1-29		....	41	29	32	14	34	37	50	41	47	35	17	14	14	0	0

No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Mean	No. obs'ns
1	0	d	d	14	11	24	66	d	64	81	67	59	60	63	87	38.4	26
2	d	d	0	13	15	29	56	d	63	64	60	44	64	62	d	34.7	25
3	21	31	12	13	22	d	d	58	61	49	45	40	55	42	50	34.1	28
4	d	d	d	16	d	27	60	d	d	67	52	d	d	74	72	45.1	10
5	27	d	d	d	d	23	63	d	d	d	71	d	d	61	90	39.1	16
6	0	d	d	19	16	17	40	d	36	75	70	d	80	76	96	36.8	26
7	0	0	0	19	16	34	64	102	d	58	51	38	d	d	94	35.2	21
8	14	14	d	15	d	d	76	88	89	68	49	32	64	71	d	36.8	25
9	15	d	d	15	d	d	d	65	78	74	d	38	d	d	98	42.5	19
10	0	0	d	d	d	d	80	73	d	d	41	d	d	82	122	39.4	20
11	0	d	d	d	10	24	41	d	d	d	50	d	d	57	77	25.9	18
12	12	13	13	d	d	d	d	77	d	d	52	42	58	81	81	34.2	21
13	0	d	d	d	17	31	81	d	d	81	60	60	66	86	97	43.4	23
14	0	0	0	18	d	40	72	d	d	60	d	32	65	79	d	33.5	21
15	0	d	d	19	d	16	61	72	d	64	68	57	71	72	115	35.4	25
16	d	d	d	d	d	d	87	d	d	40	21	d	61	60	d	53.8	5
17	11	13	14	19	d	d	100	139	d	d	85	58	68	79	d	45.9	18
18	0	9	10	13	11	18	46	77	89	59	55	38	55	68	83	35.9	29
Median 1-18	0	11	10	16	16	24	64	77	64	64	54	41	64	72	90	35.9[e]	..
19	0	d	d	d	d	d	66	d	d	99	d	d	d	77	d	43.5	8
20	0	0	0	36	d	104	d	54	74	52	52	d	d	d	71	34.2	17
21	d	d	d	39	39	44	26	81	74	70	40	40	40	67	151	45.9	21
22	d	d	d	d	d	d	d	d	d	d	63	d	64	d	d	63.5	2
23	d	0	0	0	0	0	0	65	94	145	90	47	d	130	94	34.9	26
24	0	d	d	23	13	29	81	d	d	108	62	d	77	100	111	45.8	22
25	d	d	d	d	22	d	d	d	d	72	d	d	d	71	d	34.4	8
26	10	10	d	d	11	24	d	57	40	d	d	d	d	d	d	25.2	16
27	14	14	15	18	d	31	77	88	68	71	50	54	63	80	84	40.9	28
28	d	0	0	d	d	d	d	d	d	84	91	95	72	122	124	56.3	19
29	d	d	d	d	d	d	72	d	d	d	d	d	d	75	78	42.0	10
Median 1-29	0	9	0	18	15	27	66	75	71	70	55	43	64	74	92	36.1[e]	..

[a]American Association of Variable Star Observers.

[b]Observatory constant used to reduce observations approximately to Zürich scale.

[c]Estimated from Mt. Wilson sunspot-drawings.

[d]No results received.

[e]Mean of 30 median values.

Comparison of American and Zürich observations—Table 3 compares the monthly mean of the median values for the first group of observers from the American summaries with the preliminary monthly mean sunspot-numbers from Zürich. The American data include observations on every day during the year, while eight days are

TABLE 3

MONTHLY MEAN SUNSPOT-NUMBERS FROM AMERICAN SUMMARIES AND PRELIMINARY REPORTS FROM ZÜRICH

Month	American	Zürich
1945 January	20.2	16.6
February	11.9	12.4
March	18.4	21.2
April	29.5	32.0
May	27.1	30.7
June	39.0	36.2
July	37.6	42.3
August	25.7	25.6
September	35.9	35.5
October	78.6	68.1
November	46.7	46.6
December	27.1	29.4
1945 Mean	33.1	33.0

missing in the Zürich preliminary reports. It will be recalled that the method for estimating the constant for the secondary standard observer was changed in March, 1945. The large discrepancy in October was discussed in the section on observatory constants above. The annual mean sunspot-numbers from the two compilations are in essential agreement.

Acknowledgments—The Solar Division of the AAVSO, most of whose members are amateur astronomers, has provided the major part of the material for these monthly sunspot-number compilations. The Solar Division was organized and is conducted by Neal J. Heines, who has borne the burden of instructing new observers and processing the many reports. Miss Frederika Hodder of DTM CIW performed many of the reductions for the monthly summaries.

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[2] *Astr. Mitt.*, No. 42, 1877; No. 50, 1880; No. 93, 1902.
[3] IRPL Report R25, 1945.
[4] *Astr. Mitt.*, No. 86, 1895.
[5] *Astr. Mitt.*, No. 145, 1945.

DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON, WASHINGTON 15, D. C., APRIL 29, 1946.

The Planets in September and October, 1946

By LELAND E. CUNNINGHAM

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. Throughout these two months the sun will move rapidly southward. It will cross the equator September 23, at 9:41 A.M., at which time autumn will begin. By the end of October it will be fourteen degrees south of the equator.

Moon. The phases of the moon will occur as follows:

		C.S.T.
First Quarter	September 3	9 A.M.
Full Moon	11	4 A.M.
Last Quarter	18	1 A.M.
New Moon	25	3 A.M.
First Quarter	October 3	4 A.M.
Full Moon	10	3 P.M.
Last Quarter	17	7 A.M.
New Moon	24	6 P.M.

Evening and Morning Stars. At the beginning of September the morning stars will be Mercury and Saturn; on September 14 Mercury will become an evening star, leaving Saturn the sole morning star for the remainder of the period. The evening stars on September 1 will be Mars, Venus, and Jupiter, in the order of their relative distances east of the sun. Venus will overtake Jupiter on September 3, and Mars will overtake Jupiter on September 24. All these planets will be quite close to the sun, although Saturn will be nearing quadrature by the end of October. Venus will be a brilliant object in the west throughout the two months, but during the last half of October will get rapidly lower each evening. Jupiter and Mars will be near Venus at the beginning of September, but will be too close to the sun to be seen during October. Mercury will be visible very low in the west during the last few evenings of October.

Mercury. At the beginning of September Mercury will be west of the sun, but will be moving eastward faster than the sun, and will overtake it on September 14, at which time it will be in superior conjunction. It will continue its eastward motion throughout the remainder of September and October, reaching greatest elongation east from the sun on October 31, near which date it will be very low in the west-southwest during twilight, although it will be difficult to see because it will be several degrees south of the sun. It will be easy to locate, however, since it will be about three degrees directly north of Venus.

Venus. On September 8 Venus will end its slow journey out from the sun begun last February 1, and will be at its greatest elongation east from the sun. It will, however, continue to move eastward until October 8, but more slowly than the sun. On September 5 it will appear in a telescope like a quarter moon, and after that date the crescent will slowly grow thinner. Despite this thinning crescent, it will steadily grow brighter until October 13. Throughout this period it will be a splendid object each evening.

Mars. Mars will continue to move eastward just a little more slowly than the sun. At the beginning of September it will be an inconspicuous object low

in the west each evening, but during October it will be too close to the sun to be seen. On September 24 it will be about one degree south of Jupiter.

Jupiter. At the beginning of this period Jupiter will be a bright object in the western twilight, but will move eastward more slowly than the sun, which will overtake it on the last day of October.

Saturn. Saturn will be visible low in the morning twilight during September, rising a little earlier each morning. By the end of October it will be approaching quadrature.

Uranus. Uranus will be an early morning object in Taurus. It will be occulted by the moon near midnight of October 14-15, the occultation being visible on the west coast.

Neptune. Neptune will be too close to the sun for observation throughout these two months.

Students' Observatory, Berkeley, California, July 11, 1946.

Occultation Predictions for September and October, 1946

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

				IMMERSION				EMERSION			
Date 1946		Star	Mag.	Greenwich C.T.	*a*	*b*	Angle E from N	Greenwich C.T.	*a*	*b*	Angle E from N
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′											
				h m	m	m	°	h m	m	m	°
Sept.	2	ω^1 Scor	4.1	23 9.9	−1.5	−1.9	152	0 14.9	−1.9	−0.5	247
	3	24 Ophi	5.6	22 48.0	−2.5	+0.5	73	0 4.6	−1.9	−1.6	319
	8	33 Capr	5.5	23 15.2	−0.9	+1.0	108	0 19.9	−1.5	+1.9	226
	15	38 Arie	5.2	5 17.5	−0.7	+2.0	43	6 26.0	−1.5	+1.2	252
	17	129 H³Taur	5.7	4 43.9	−2.2	−1.4	144	4 58.9	..	..	172
Oct.	3	201 B.Sgtr	5.9	21 10.7	−1.8	+1.0	86	22 39.6	−2.1	+0.2	275
	7	161 B.Capr	6.4	3 41.9	−1.5	−0.5	76	4 52.4	−0.6	+0.1	225
	7	69 Aqar	5.8	23 27.5	−1.2	+1.6	65	0 44.2	−1.6	+1.3	243
	8	τ Aqar	4.2	1 11.8	−0.8	+2.3	13	2 7.4	−2.7	−0.3	286
	12	ξ Arie	5.5	4 47.9	−1.3	+1.4	57	6 2.1	−1.5	+1.0	237
	15	121 Taur	5.3	11 1.1	−1.6	−0.1	69	12 9.8	−0.9	−1.6	283
	17	176 B.Gemi	6.3	8 50.8	−1.8	−0.5	120	10 2.2	−1.9	+1.4	248
	17	181 B.Gemi	6.0	9 42.4	..	..	158	10 20.0	..	..	213
	20	46 Leon	5.7	10 55.1	−1.1	−2.3	160	11 51.2	−2.3	+2.0	251
	30	σ Sgtr	2.1	21 26.6	−2.2	−0.3	96	22 55.5	−1.7	−0.5	255

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′

				h	m	m	m	°	h	m	m	m	°
Sept.	15	38	Arie	5.2	5	5.4	0.0	+2.4	22	5	55.7	−1.4	+1.0	278
	18	BD+23°1007		6.5	5	48.0	−0.8	−0.3	138	6	12.0	+1.1	+3.2	193
Oct.	7	161	B.Capr	6.4	3	11.5	−1.7	+0.8	53	4	32.9	−1.6	−0.1	248
	7	69	Aqar	5.8	23	5.6	−0.7	+1.7	69	0	14.4	−1.1	+1.6	249
	8	τ	Aqar	4.2	0	52.5	..	..	354	1	16.0	−2.8	−1.5	317
	12	ξ	Arie	5.5	4	25.4	−0.6	+2.2	32	5	29.1	−1.7	+1.0	261
	15		Uranus	5.9	6	3.5	−1.6	−0.1	125	6	43.3	+0.1	+3.4	200
	15	121	Taur	5.3	10	27.8	−2.0	+0.3	79	11	47.5	−1.8	−0.5	265
	17	176	B.Gemi	6.3	8	21.9	−1.3	+0.3	114	9	27.8	−1.3	+2.0	245
	17	181	B.Gemi	6.0	9	10.0	−2.6	−4.1	158	9	38.7	..	..	203
	17	κ	Gemi	3.7	11	40.8	−2.1	+0.1	92	13	2.7	−1.8	−1.2	287
	20	46	Leon	5.7	10	47.2	..	..	188	11	3.9	..	..	215
	30	σ	Sgtr	2.1	20	46.9	−1.9	+0.4	104	22	18.0	−2.3	+0.2	260

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′

Sept.	3	84	B.Scor	6.3	3	11.4	−2.0	−2.2	142	4	22.7	−1.5	−0.6	249
	9	37	Capr	5.8	4	35.5	−2.2	+0.4	104	5	46.0	−1.6	+1.8	212
	9	ε	Capr	4.7	6	45.5	−0.8	+2.1	16	7	43.8	−2.9	−1.5	289
	9	κ	Capr	4.8	10	12.2	−0.3	+0.4	42	11	11.8	−0.5	−1.0	265
	13	33	Ceti	6.2	11	33.0	−1.7	+0.1	68	12	44.6	−0.9	+0.7	225
	18	412	B.Taur	6.0	12	5.3	−1.9	+0.5	98	13	21.0	−1.8	+1.8	237
	20	5	B.Canc	6.4	11	53.6	−1.1	+0.3	114	12	58.8	−1.1	+1.9	248
	29	ν	Libr	5.3	2	8.0	−1.3	−4.0	174	2	41.6	−0.7	+0.6	226
Oct.	7	161	B.Capr	6.4	2	18.1	−1.5	+2.3	33	3	26.9	−2.4	+0.3	282
	12	ξ	Arie	5.5	4	17.1	+1.1	+4.1	350	4	36.3	−2.0	−0.9	311
	15		Uranus	5.9	5	42.6	+0.1	+1.0	90	6	34.1	+0.1	+1.7	237
	15	121	Taur	5.3	9	33.6	−0.2	+1.7	63	10	49.0	−2.0	+0.7	264
	16	ε	Gemi	3.2	12	3.9	−2.1	+0.3	93	13	27.9	−2.2	+0.2	263
	17	176	B.Gemi	6.3	8	0.3	0.0	+1.0	90	8	58.6	−0.4	+1.3	263
	17	181	B.Gemi	6.0	8	28.8	−0.7	+0.1	125	9	16.7	0.0	+2.5	229
	17	κ	Gemi	3.7	10	47.4	−1.3	+0.8	95	12	4.3	−1.8	+0.9	267
	30	σ	Sgtr	2.1	20	19.6	+0.4	−1.2	153	21	4.7	−2.5	+3.0	225

OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′*

Sept.	3	84	B.Scor	6.3	4	13.9	..	..	172	4	34.7	+1.1	+3.9	205
	6	*H*	Sgtr	4.7	22	57.8	..	..	22	23	20.5	+1.5	−4.5	347
	9	ε	Capr	4.7	7	9.1	−1.6	−0.1	71	8	22.6	−0.6	+0.3	230
	12	33	Pisc	4.7	2	19.2	−0.5	+1.2	82	3	21.4	−0.9	+2.0	224
	13	26	Ceti	6.2	7	17.5	−2.8	+0.3	90	8	20.6	−0.6	+2.8	192
	13	33	Ceti	6.2	12	20.4	..	..	129	12	44.4	..	..	174
	15	38	Arie	5.2	4	42.8	0.0	+2.1	34	5	36.9	−0.9	+1.1	267
	18	412	B.Taur	6.0	13	17.7	..	..	156	13	45.6	..	..	192
Oct.	6	φ	Capr	5.4	7	22.7	+0.8	+2.3	10	7	57.7	−1.0	−2.7	301
	7	161	B.Capr	6.4	2	48.0	−2.2	+1.1	62	4	17.2	−1.9	+0.8	238
	7	69	Aqar	5.8	22	48.6	−0.3	+1.0	92	23	49.4	−0.9	+2.0	230
	8	τ	Aqar	4.2	0	10.8	−1.1	+2.8	23	1	4.7	−1.7	+0.3	291
	12	ξ	Arie	5.5	3	59.9	−0.5	+2.0	42	5	5.7	−1.5	+1.4	251
	12	31	Arie	5.7	11	44.6	−0.9	+1.2	35	12	38.6	−0.5	−1.5	281
	15	121	Taur	5.3	10	14.3	−2.7	−1.1	111	11	27.1	−2.2	+2.0	226
	16	ε	Gemi	3.2	12	57.8	−2.0	−1.6	114	14	14.6	−1.8	−0.3	258
	17	176	B.Gemi	6.3	8	16.3	−2.0	−1.9	145	8	53.2	0.0	+4.3	208
	17	κ	Gemi	3.7	11	33.1	−2.4	−1.9	131	12	47.7	−2.8	+1.4	245
	29	39	Ophi	5.4	1	55.3	−0.4	−0.3	65	2	56.2	−0.5	−1.7	295

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

Asteroid Notes

By HUGH S. RICE

During the present period, VESTA is by far the best minor planet for work with small telescopes. It is found retrograding in Cetus. On the evening of September 22, it is nearly 2° directly south of the star Iota Ceti. The visual magnitude, about 7.1, is the brightest during the apparition, the date mentioned being the time of opposition. The following ephemeris shows the successive positions of Vesta in the sky. For the ephemeris, we are indebted to Dr. Dirk Brouwer, of the Yale University Observatory.

EPHEMERIS OF VESTA, FOR 0^h U.T.
Equinox of Date

1946	α h m	δ ° ′	1946	α h m	δ ° ′
Aug. 24	0 38.0	— 7 26	Sept. 25	0 14.6	—11 20
28	0 36.2	— 7 54	29	0 10.9	—11 44
Sept. 1	0 34.0	— 8 24	Oct. 3	0 7.3	—12 4
5	0 31.4	— 8 54	7	0 3.9	—12 21
9	0 28.5	— 9 25	11	0 0.6	—12 34
13	0 25.3	— 9 55	15	23 57.6	—12 44
17	0 21.9	—10 25	19	23 55.0	—12 50
21	0 18.3	—10 53			

Hayden Planetarium, American Museum of Natural History,
New York, N. Y., July 22, 1946.

Comet Notes

By G. VAN BIESBROECK

There are at the present time no less than six comets under observation but all are too faint to be of interest to observers with small instruments. In order of discovery they are as follows:

COMET 1946 *a* (TIMMERS) which was discovered early in February is still in good observing position. On June 25 I estimated the total brightness as 10^m5 in close agreement with the expected value. The ephemeris given below will enable observers to follow the slowly fading object in its course from the constellation of Draco through Hercules. Large telescopes will show the object probably until November.

PERIODIC COMET 1946 *b* (TEMPEL II) has brightened up considerably since the observations began on May 1. On June 25 it appeared as a round coma some 5′ in diameter with a well-defined nucleus and a total brightness corresponding to a ninth magnitude star. This was near the time of perihelion passage (July 2) and of maximum brightness. The ephemeris by Cunningham given below indicates the course of the comet through Cetus. It should be easily accessible to a 4-inch telescope in the next month or two.

COMET 1946 *c* (PAJDUSAKOVA-ROTBART). This second new comet of the year was discovered independently by two observers: the first, Ludmila Pajdusakova on May 29 at the Skalnate Pleso Observatory, erected at an altitude of 6000 feet in the Tatra Mountains of Czechoslovakia during the war; the second, David Rotbart on May 30, amateur astronomer in Washington, D. C. The comet, designated as being of magnitude 8th and 6th, respectively, by the two discoverers

moved rapidly across the sky showing that it was relatively near to the earth. It showed a well-defined nucleus and a large coma from which emanated a tail nearly a degree in length. From the observations up to June 5, L. E. Cunningham and Miss E. L. Scott computed the following parabolic elements:

Perihelion passage 1946 May 11.43592 U.T.	
Perihelion to node 22° 16′	1946.0
Longitude of node 301° 15′	
Inclination 169° 34′	
Perihelion distance 1.0182506 A.U.	

When discovered the comet was therefore on its way out from the sun, passing, on June 1, at a distance of only 0.16 astronomical unit from the earth. While it was easily visible as a faint nebulosity to the naked eye shortly after the discovery it rapidly faded, and by the time these notes are published it will only be in reach of large telescopes on its way out into space. When last observed here on June 30, before the moon interfered, the comet still showed a good-sized tail opposite to the sun as well as a short lateral jet making a large angle with the main tail. The following ephemeris positions (*H.A.C.*, 752)

1946	α h m	δ ° ′	Mag.
July 31	11 53.6	+9 20	14.8
Aug. 8	11 56.0	+8 30	15.3

locate the comet in Virgo where it will be lost in the evening sky.

Periodic Comet 1946 *d* (Giacobini-Zinner). This expected comet was picked up by H. N. Jeffers at the Lick Observatory, who gave the following information:

1946 May 29.3974 U.T. $19^h\ 48^m\ 26^s.6$ +29° 26′ 1″ Magnitude 17.

A change of less than 4 hours in the time of perihelion passage predicted by F. R. Cripps in the *Handbook of the B. A. A.* was required to represent this observation. Since the recovery the comet has brightened up considerably and, as shown by the ephemeris given below, it will remain in very good position for northern observers and reach magnitude 8 in September. The circumpolar position will make observations possible at any time of the night. This comet is of special interest on account of the fine but short-lived meteor shower that was seen in 1933 connected with the near approach at the time. Conditions for the recurrence of that shower are promising this fall. L. E. Cunningham (*H. A. C.*, 756) worked out the details of the encounter: "The earth will cross the orbital plane of the comet on October 10 at $3^h.0$ U.T. at a distance of 132,000 miles from the orbit, but will be 1000 miles closer $0^h.5$ earlier. It will remain within 500,000 miles of the orbit, which was the distance during the meteor shower of 1933, from 1946 Oct. 9, $12^h.5$ U.T. to Oct. 10, $16^h.5$ U.T. some 28 hours." The meteors should be looked for on the night of Oct. 10-11. The radiant is in the constellation of Draco.

Periodic Comet 1946 *e* (Brooks II). Like the previous object this comet was also picked up at the Lick Observatory by H. M. Jeffers near the ephemeris position computed by F. R. Cripps. It was a very faint diffuse object at recovery but is expected to brighten up this fall. Here too a change of 4 hours in the computed time of perihelion passage brings the prediction into agreement with the observation. The recovery position was

1946 June 28.414 U.T. $1^h\ 2^m\ 54^s.2$ +7° 53′ 18″ Magnitude 18.

It is a low morning object in Cetus at present but will gradually change its position so as to be visible in the middle of the night. Maximum brightness is not expected until October. The ephemeris given below should be quite accurate but the expected magnitude is uncertain.

Periodic Comet 1943 *a* (Oterma) was recorded again on June 29, 30, and July 1 by the writer at the McDonald Observatory as a nearly stellar coma of magnitude 18.5. It is almost exactly in the position predicted by P. Herget (*H. A. C.*, 741) from his orbit based on the 1943 and 1944 measures. The period is 7.89 years. It is an extremely faint object but its presence at this time is of interest because the comet is within a month of its aphelion. Visibility near aphelion was to be anticipated since the eccentricity of the orbit is only 0.14. However, so far periodic comet 1925 II (Schwassmann-Wachmann) was the only one that had been followed around its whole orbit. Comet Oterma is the second instance of such a possibility. It will remain well situated for several months to come but even at opposition on August 27 it is not expected to be brighter than magnitude 17.

Two more periodic comets are expected this summer: Comet Schwassmann-Wachmann III and Comet 1941 *e* (DuToit-Neujmin). They are evening objects and will be best located for southern observers.

EPHEMERIDES

Comet Timmers

H. A. C. 744

1946	α h m	δ ° ′	Mag.
July 31	15 50.9	+57 8	11.0
Aug. 8	16 4.6	52 21	11.2
16	17.5	47 34	11.4
24	29.8	42 51	11.6
Sept. 1	41.8	38 17	11.8
9	16 53.5	+33 57	12.0

Comet Tempel II

H. A. C. 747

1946	α h m	δ ° ′	Mag.
July 31	1 0.8	— 9 8	9.0
Aug. 8	1 15.2	10 37	9.1
16	26.5	12 19	9.1
24	34.3	14 9	9.2
Sept. 1	38.5	16 1	9.3
9	1 39.2	—17 45	9.5

Comet Brooks II

B. A. A. Handbook, p. 37

1946	α h m	δ ° ′	Mag.
July 31	2 6.1	+12 19	15.0
Aug. 8	20.3	13 2	14.9
16	33.7	13 24	14.8
24	45.9	13 55	14.6
Sept. 1	2 56.8	14 4	14.5
9	3 6.0	+14 2	14.4

Comet Giacobini-Zinner

H. A. C. 756

1946	α h m	δ ° ′	Mag.
July 31	20 52.0	+66 2	11.4
Aug. 8	21 19.3	71 9	10.8
16	22 19.5	76 20	10.2
24	0 50.3	79 42	9.6
Sept. 1	4 6.3	75 14	9.0
9	5 37.9	+62 14	8.5

McDonald Observatory, Fort Davis, Texas, July 11, 1946.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

It is well known that on 1933 October 9 over Europe and the eastern Atlantic the finest meteor shower of the twentieth century unexpectedly appeared. This could not be seen in America because by the time darkness came here the Earth had passed through the meteor stream and the shower was over. Fortunately, though caught unprepared, numerous professional astronomers in many countries, and also amateurs, made excellent observations of many kinds. At various Russian stations rates were as high, at maximum, as 100, 200, or even 300 per minute. In Ireland, it reached 100 in 5 seconds, as estimated. At Malta, R. Forbes-Bentley observed from 6:30 P.M. to midnight, keeping 5-minute counts, and saw 22,500 meteors, only four being sporadic. His maximum was 480 per minute at 8:15. These notes indicate the richness of the shower as to numbers. However, according to a résumé by A. King, from which indeed the above data were taken (*Nature*, November 4, 1933) only 5% of the meteors reached the first magnitude, most were fourth or less. Few fireballs accompanied the meteors. The whole display lasted 4½ hours, the Earth taking that time to traverse that section of the stream which lay across our path.

Attention should be called to a paper by S. Arend and (Madame) G. Camille Flammarion which appeared in *L' Astronomie* for May, 1936. Here they discussed a plate taken at the Juvisy Observatory on which no less than 25 meteor trails were impressed. Eight of the longer and stronger ones were chosen for measurement and the radiant derived. Also at Uccle in Belgium another plate was measured and the coordinates determined. The results are so excellent that I quote them:

	At Juvisy	At Uccle
Apparent radiant	$\alpha = 266^\circ.64$ $\delta = +54.90$	$\alpha = 266^\circ.66$ $\delta = +54.86$
Corrected radiant	$\alpha = 262.29$ $\delta = +53.74$	$\alpha = 262.29$ $\delta = +53.87$

All are for the equinox 1933.0 and the corrections were for zenith attraction and diurnal aberration. Such beautiful agreement in the results from two distant stations indicates what might be attained in the photographic determination of meteor radiants.

Now as to our chances for a shower in October, 1946. First an orbit, with perturbations allowed for, was published last year by F. R. Cripps, a British astronomer. On the basis of this, the comet was rediscovered at Lick Observatory by H. M. Jeffers on May 29, when of magnitude 17, the object being diffuse and with a central nucleus. The difference between the predicted and observed positions was only 407″ and —24″, a total of less than 7′, which would indicate that a very fine orbit had been calculated. Dr. L. E. Cunningham at Berkeley, California, making this correction, finds that the comet will pass perihelion on September 18.495, its period being 6.588 years. He further writes (see *H.C.O. Announcement Card* 756), "The earth will cross the orbital plane of Periodic Comet Giacobini-Zinner on 1946 October 10 at 03^h0 U.T., at a distance of 132,000 miles

from the orbit, but will be 1000 miles closer 0^h5 earlier. It will remain within 500,000 miles of the orbit, which was approximately the distance during the meteor shower of 1933, from October 9, 12^h5 U.T. to October 10, 16^h5 U.T., some 28 hours. Observations of the comet during the next three months may alter these figures slightly."

If the writer had not had nearly a half century of practical experience with the vagaries of meteor streams, and did not know the almost insuperable difficulties of exact prediction as to their behavior, on the basis of these favorable circumstances he would confidently say that a grand meteor shower would appear next October. Sad experience having made him cautious, he will say only that it seems very probable we will have a fine chance for a really great shower and that we must prepare for it fully.

The radiant is near the head of Draco, and at 9 P.M., E.S.T., (about the time when we are nearest the comet orbit) is in the N.W. and about two-thirds the way up from horizon to zenith. The Moon is most unfortunately full on October 10 and hence will be an awful nuisance and handicap. At the hour of maximum, given above, it will be about 108° distant, and in the S.E., hence will do less damage than might have been feared. Due to uncertainties inherent in prediction of meteor showers, our observers should begin to watch after dark on October 8 and be ready for something good that night, for something better on October 9, and still be hopeful through October 10; in other words plan for work on the three successive nights so as not to be caught napping or unprepared.

As for specific plans, if one is fairly skilled in plotting, it is suggested that plotting be done for a 15-minute interval (if large numbers are appearing) then a count be made for 15 minutes. Such a procedure may be continued while the main shower is in progress. If meteors come in only ordinary numbers, then as usual all should be plotted. For members and others with little or no plotting experience, I suggest that they keep careful counts for every 10-minute interval. The exact minute of starting and stopping each count, the condition of the sky, and the direction faced must be given. Each observer should keep his own count absolutely separate from those of companions. He need not worry if others count the same meteors he sees; all he has to do is count every one *he does see!*

For those who desire to try photography, the exact times the shutter is opened and shut must be recorded. A careful watch of the field of the camera should be kept and the time of appearance of any meteor as bright as magnitude +1, which crosses the field, should be recorded, along with other data on said meteor. The camera should preferably be turned to an area of the sky with the radiant just on the edge of the field, and may be kept in a fixed position during exposure. For those with equatorially mounted telescopes, run by clockwork, the camera should be attached to the mounting and the clockwork used. Stationary cameras are, however, all right if the above instructions are carefully carried out. If one has two or more cameras, they should be pointed to different areas near the radiant. Moonlight will produce fogging if the exposures are allowed to run too long.

Again the writer emphasizes that he dare not promise a great shower: meteor streams are too erratic in their behavior for one to ever be sure of anything. But the chances do seem excellent, and it would be unforgivable if the A.M.S. lost out on what may well be the best shower of the century through carelessness or unpreparedness. All are therefore urged to be ready and ready in every way! Have

the observing station picked out and prepared as well as may be, be sure you have all the maps, blanks, pencils, rulers, and, above all, proper lanterns or flash lights, and in general have the necessary things ready some days in advance to allow for delays. The nights are Tuesday, Wednesday, and Thursday, unfortunately in the middle of the week. I suggest, where practicable, that vacations of a few days be arranged for this brief period. This cannot be done by many but it can by some. And lastly for individuals or parties who desire detailed advice for special work, if they will write me, I will try to reply to their questions. This should, however, be done some weeks in advance as I am likely to be very busy after October begins.

1946 July 7.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

On the Puente-Ladron, New Mexico, Aerolite

LINCOLN LA PAZ
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ABSTRACT

C. H. Smith's assertion that "The main facts are against the possibility that this little aerolite was carried into the area by Indians and there discarded or lost; . . ." is shown to be without foundation. Accordingly, Smith's plea for an all-out search of the inhospitable and unpromising Puente-Ladron area is without justification. In view of the failure of continued search in this region to result in additional finds, it would be more reasonable to exhort meteoriticists to increased activity in areas known to be meteorite-strewn fields.

Certain remarks on the Puente-Ladron, New Mexico, aerolite recently published under the name of Claude H. Smith in these CONTRIBUTIONS[1] cannot be allowed to pass unchallenged. That the finding of this aerolite in 1944 was "well-nigh unique in the annals of meteoritics" may be admitted, but Smith does not make clear what bearing such uniqueness has on the question of the manner in which the meteorite reached the position in which it was found at that time. Not only in the Puente-Ladron area itself, but thruout a very extensive plains region encompassing the point of discovery, dark pebbles and spalls of obsidian and malapi of density 2.5 or less are almost the only objects that might be confused with such a meteorite as Puente-Ladron. Since aerolites of the class to which Puente-Ladron belongs have densities much greater than 2.5, and since, according to the discoverer's own account,[2] "some grains of metal and of sulfide" are revealed "by reason of a small break in the fusion crust," it follows that, both "because of its greater weight [density] and its appearance,"[1] in contrast to those of other surface rocks, conditions were favorable for arousing the interest of

anyone who picked up and examined Puente-Ladron. Furthermore, in contradiction to Smith's statement that "There was little about the stone to warrant even a closer inspection, except the [meteoritical] interest factor," stones superficially resembling the Puente-Ladron aerolite must have received very close attention from the Indian inhabitants of the region as possible arrowhead material. This conclusion is based on the fact that many of the arrowheads found in this area have been fabricated from the dark pebbles and spalls of obsidian that are scattered thruout the region. That small, as well as large, fragments of this substance were picked up and utilized by the Amerinds may be inferred from the discovery of "Christmas-tree" points in the Puente-Ladron area so tiny that they could have been chipped out of a piece of obsidian much smaller than the Puente-Ladron meteorite. Furthermore, one connotation of Smith's statements, *viz.,* that stone meteorites are unlikely to be found and preserved by Indians, is definitely in conflict with the fact that all 4 of the meteorites discovered on old Indian camp sites in western Kansas and eastern Colorado and reported by the American Meteorite Laboratory were of the stony variety. Therefore, even if we accept Smith's wholly unjustified assumption that, during its entire terrestrial history, the aerolite in question occupied the same position as that in which it was found in 1944, it is by no means necessary to make the supposition that ". . . an Indian might have seen this small aerolite strike the ground . . ." in order to render possible or even probable its discovery by the Red Men.

Smith's assertion that "Certainly there is no more reason for an Indian to keep a meteorite than there is for a white man!" is questionable in general because considerable evidence is at hand indicating that most or all aborigines attached special significance to meteorites,[3] while, as is well and sorrowfully known to meteoriticists, surprisingly few white men are even interested in them! In the present connection, Smith's assertion is certainly in error because stones which the Amerinds sought along the Rio Puerco as arrowhead material superficially resembled the Puente-Ladron meteorite, as already noted. If Puente-Ladron was picked up as potential "point" material, then, whether it was recognized as meteoritic or not, it is most probable that its various unusual features would have led as keen and curious observers as the Indians to keep it.

Again Smith displays unfamiliarity with the conditions existing in the Puente-Ladron area when he writes, ". . . an aerolite exposed on the surface of the ground since the time when the Indians inhabited this region in any great numbers would be in a much more weathered condition than was the Puente-Ladron aerolite." Actually, the region in which the Puente-Ladron meteorite was found is subject to very intense sand-storms, during which the complementary processes of wind-scour and sand-drift rapidly alter the surface features of the terrane. On trips to the New Mexico School of Mines at Socorro, and to military installations near Alamogordo, I have often seen visibility at high noon cut almost to zero by the dense sand-storms sweeping across the highway at the site of the Puente-Ladron find, and members of the Department of Anthropology of the University of New Mexico, who have worked in the area in question, state that objects exposed there at one time may, *within a few hours,* be deeply buried by drifting sand! Under such conditions, it is meaningless to speak, as Smith does, of "*the* surface of the ground"; and the fact that Puente-Ladron was uncovered when found in 1944 gives no justification whatever for concluding, as he does, that this meteorite had been exposed to weathering action on the surface of the

ground, "since the time when the Indians inhabited this region in any great numbers."

In addition to the objections raised by Smith, which have just been disposed of, I have been orally criticized by a field meteoriticist for suggesting that Puente-Ladron was transported by Indians into the area where it was found in 1944 without having actually examined the surface of the specimen to ascertain whether or not it gives evidence of having been carried in a medicine man's pouch or similar container. This criticism is based on the questionable assumption that mere examination of the surface condition of a meteorite will suffice to determine whether or not it has been carried by human beings. Among archeologists, who work under conditions permitting much closer checking than is possible for meteoriticists, belief in the universal validity of the patination criterion was discredited long ago. Furthermore, it is surely not without significance that Nininger, who omitted any reference to patination from his minutely detailed account of the discovery of Puente-Ladron,[2] had earlier been unable to decide in a similar case whether a noticeable patination on aerolitic fragments was a result of their having been carried by human beings or their having been sand-blasted. In discussing the Hawk Springs, Wyoming, aerolite (in *The Mines Magazine* for April, 1937), he writes thus: ". . . a noticeable patination on the fragments leads me to think that either they had been carried and dropped there or else had been affected by the wind-blown sand. It is possible that the apparent patination is in reality only the result of sand-blasting. . ." Such uncertainty expressed by a field man with Nininger's wealth of experience lends little support to the criticism noted at the beginning of this paragraph.

To summarize, Smith's assertion that "The main facts are against the possibility that this little aerolite was carried into the area by Indians and there discarded or lost; . . ." is certainly without foundation. His conclusion that "every effort should be made to search this region carefully for other possible members of this fall" will probably have little influence on those familiar with conditions, past and present, in the Puente-Ladron area. In support of this last remark, I wish to call attention to the following facts:

(1) Mr. Boyd Wettlaufer of the University of New Mexico, in connection with his anthropological field work in the Puente-Ladron area, has been on the lookout for additional specimens of the Puente-Ladron fall for several months. Mr. Wettlaufer is familiar with stony meteorites and, in fact, discovered what appears to be a new aerolite in Canada while serving with the Royal Canadian Air Force. Since his interest centers on the collection of complete or fragmentary points, knives, and other artifacts, made from obsidian and similar materials, he particularly examines precisely that class of objects most closely resembling the Puente-Ladron aerolite. Neither Mr. Wettlaufer nor his collaborators have so far found additional specimens of this fall during their extensive investigations in the Puente-Ladron area.

(2) Dr. H. H. Nininger, who appears to have spent more time searching in the inhospitable Puente-Ladron region than anyone except Mr. Wettlaufer and his associates, wrote me a letter under date of April 6, 1946, in which he enumerated the areas in New Mexico in which he planned to continue field programs. The Puente-Ladron region was *not* on his list!

REFERENCES AND NOTE

[1] Smith, C. H., *C.S.R.M., P. A.*, **54**, 193-5, Apr., 1946.
[2] Nininger, H. H., *C.S.R.M.*, **3**, 165-7; *P. A.*, **52**, 407-10, 1944.
[3] See the statements relating to the Anderson, Ohio; Hopewell Mounds, Ohio; Winona, Arizona; Navajo, Arizona; Mesa Verde Park, Colorado; Pojoaque, New Mexico; Red River, Texas; Wichita County, Texas; Iron Creek, Battle River, Alberta, Canada; Willamette, Oregon; Cape York, West Greenland; Casas Grandes, Chihuahua, Mexico; Huizopa, Chihuahua, Mexico; and various unnamed meteorites, which are made in the third and fourth references cited in my previous note on the Puente-Ladron aerolite, *C.S.R.M., P. A.*, **54**, 96, Feb., 1946.

A Fire Caused Reportedly by a Meteorite

BRYANT MATHER
18 Monroe Street, Mount Vernon, New York

ABSTRACT

This paper contains an account of a fire caused reportedly by the fall of a meteorite at 10:20 P.M., on August 11, 1945, in Tulsa, Oklahoma.

The headline, "Meteorite Starts Fire, First on Record,"[1] appearing in a technical magazine of good repute, followed by an account that bore all the evidence of better-than-average investigation, stimulated the writer to make further inquiries. It was found that this account was based on an earlier article entitled, "A Star Fell in Oklahoma," which appeared in the *News Letter of the National Fire Protection Association*.[2] The story as compiled by the writer from the accounts just cited and from personal communications[3, 4] is given here.

Captain Walter Derrick, of Station 5 of the Tulsa, Oklahoma, Fire Department, is quoted as follows:

"We were sitting in front of the station facing the south when suddenly plummeting from the sky came a shooting-star. It had a brilliant light and fell with a dazzling speed.

"I remarked to one of the boys that it looked as if it were coming right toward the station.

"It was only a minute or two later that we received a call that a house at 2765 South Boston Avenue had been set on fire by a star fragment."

The fire is recorded as having occurred at 10:20 P.M. on August 11, 1945. The damaged building is the home of Mr. C. E. Thompson, but at the time of the fire no one was at home, the family having gone to the "movies." Mrs. S. E. Dunn of 138 East 26th Court, who sent the alarm to the fire department, reported that she was advised of the fire by an unnamed woman who ran to the Thompson house and stated that the meteorite hit the corner of the house and flames shot from the roof.

Assistant Fire Marshal Marshall A. Maddux, of the Tulsa Fire Department, and Mr. Harry W. Henry, Inspector of the Oklahoma Inspection Bureau, investigated and interviewed neighbors who verified that a meteorite struck the corner of the house and fire ensued. Mr. I. B. Murrey, Tulsa Branch Manager of the Oklahoma Inspection Bureau, 814 World Building, Tulsa 1, Oklahoma, reported the findings to the National Fire Protection Association, Executive Office, 60 Batterymarch Street, Boston 10, Massachusetts. The Oklahoma Bureau also provided the following information:

"One person who saw the meteorite strike the house is Mrs. Nina Kennedy, Adams Hotel, Tulsa, Oklahoma, who was interviewed on October 15, 1945, by Mr. Harry W. Henry.

"Mrs. Kennedy makes the unqualified statement that the fire started just at the instant and place where the house was hit."

Mr. Robert S. Moulton, Technical Secretary of the N.F.P.A., states that it is the policy of his Association to publish accounts of fires only when the accounts have been authenticated thru responsible sources. The account, as published by the N.F.P.A.,[2] avoids the direct statement that the meteorite ignited the building, saying merely that the meteorite struck and the fire ensued, and that the occurrence was the "first reported and authenticated fire loss in the 51-year history of the N.F.P.A. Fire Record Department resulting from a meteorite's striking a building." In Mr. Moulton's opinion it would be an unlikely coincidence that the fire started in the house from some separate and wholly unrelated cause at the same time that the meteorite was observed.

The writer notes and invites attention to the striking similarity of the account, as set forth here, to the one discussed in 1934 by Professor C. C. Wylie,[5] and he hopes that an equally exhaustive and satisfactory investigation may be made of it.*

REFERENCES

[1] *National Safety News*, **52**, No. 6, 123, Dec., 1945, published by the National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois.

[2] *News Letter*, No. 341, 1, Nov., 1945, published by the National Fire Protection Association, 60 Batterymarch Street, Boston 10, Massachusetts.

[3] Personal communication dated March 5, 1946, from Mr. Carman Fish, Editor, *National Safety News*.

[4] Personal communications dated March 13, 21, and 25, 1946, from Mr. Robert S. Moulton, Technical Secretary, National Fire Protection Association.

[5] *P. A.*, **42**, No. 2, 103-5, Feb., 1934; see also *Brooklyn Times-Union*, for July 7, 1933; *Paris Midi du Vendredi*, for July 7, 1933; and *Ward's Mineral Bulletin*, **3**, No. 1, 8, Oct., 1934.

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[It is all the more remarkable that the "meteorite" that is supposed to have caused this fire fell in the *evening* (at 10:20 o'clock) of *August 11*—one of the dates of the Perseid shower. The Archie, Missouri, aerolites, which fell on 1932 August 10, at 4:30 P.M., were *not* Perseids, however; see the papers by E. S. Haynes and H. H. Nininger respectively in *C.S.R.M.*, **1**, No. 1, 11-14, 1935, No. 2, 6-10, 1936; *P. A.*, **43**, 181-4, 1935, **44**, 93-7, 1936, and the other sources referred to therein.—ED.]

The Recently Reported Bradford Woods, Allegheny Co., Pennsylvania, Aerolite

In a letter entitled "A New Pennsylvania Meteorite," published in *Science*, **103**, 694-5, June 7, 1946, Professor Henry Leighton, of the Department of Geology of the University of Pittsburgh, writes:

"Recently one of my students, C. R. Bruce, brought to the laboratory for identification a specimen which had been resting in family cupboards for 61 years. The story was that in September, 1886, a man was cutting corn on the Deutihl property, 2½ miles southwest of Bradford Woods, or 7 miles northwest of Pitts-

*The information given in this paper, which was obtained from the National Fire Protection Association, is quoted by permission.

burgh in Allegheny County, Pennsylvania. He heard an explosion and a rushing noise and ran to the home of George Hillman, who, on going to the field, found the specimen imbedded in the road and still warm. It has been in possession of the family ever since and is now owned by Mrs. Charles Amsler of Baden, Pennsylvania.

"Inasmuch as it is in private hands, no opportunity has been afforded for detailed study, but preliminary examination indicates that it is a true stony meteorite or aerolite. As such, it is of considerable interest, since it is the first recorded aerolite found in Pennsylvania. R. W. Stone (*Meteorites found in Pennsylvania, Pennsylvania Topographic and Geologic Survey, Bull. G 2*, 1932) lists 5 meteorites found in the State, but all these were of the metallic type, or siderites.

"The Bradford Woods meteorite measures 55 × 65 × 85 mm. and weighs 762 grams. It is shaped somewhat like an old-fashioned pan biscuit, with one smooth, curved surface like the biscuit top and 3 more square faces like the broken faces of a biscuit. The surface has the glazed, varnishlike, pitted surface characteristic of meteorites and is nearly black. It would seem that it is a part of a smooth, pebblelike, elliptic body which, as it reached the Earth's atmosphere, exploded, the broken surfaces becoming fused and pitted in the rush thru the atmosphere.

"A freshly broken corner of the mass made it possible to examine its mineral composition. It is made up of fine-grained, greenish, silicate material which is highly birefringent and has a high index of refraction and an obscure cleavage. This is probably olivine. Accompanying the silicate is a small amount (possibly 2% or 3%) of metallic iron, which is visible also on the unbroken surfaces. The specific gravity of the whole specimen is approximately 3.4.

"From this preliminary examination it is evident that the meteorite is an aerolite with a small amount of metallic iron and may possibly be classed as an olivine achondrite.

"It is hoped that the specimen eventually may be acquired by the Carnegie Museum of Pittsburgh or some other public repository so that a detailed petrographic and chemical study of it may be made."

The provisional coördinate number (P.C.N.) of the Bradford Woods aerolite is 0801,405.

ADDENDUM

Our manuscript catalog of meteoritic falls contains the following entry for an aerolitic fall (this likewise of the achondritic type) in Pennsylvania:

"Chicora, Butler County; achondrite; fell 1938 June 24, 6:00 P.M.; 2 stones; weight not reported; coördinate number = 0798,410."

Hence the Bradford Woods stone constitutes the *seventh* meteoritic, and the *second* aerolite (and also *observed*) fall on record for the State of Pennsylvania. —F.C.L.

S. J. Shand on the Importance of the Study of Meteorites to Petrology

"Eruptive Rocks: Their Genesis, Composition, and Classification, with a Chapter on Meteorites," 2nd Ed., Rev. & Enlarged, xvi + 444 pp., by S. James Shand, Professor of Geology, Columbia University, New York, 1943 (Wiley), as its title declares, contains a chapter (XX, pp. 418-36) on "Meteorites." Following is the opening paragraph of that chapter:

"The greatest weakness of petrography, as a method of investigating the composition of the Earth, is that direct observation can be made only upon rocks that have crystallized within a few thousand feet from the surface, say a thousandth part of the Earth's radius. There is good reason, no less on petrological than on geophysical and astronomical grounds, to suppose that the matter that forms the interior of the planet is different in many respects from surface rocks; but direct observation of this matter is naturally impossible. It is here that meteorites come to our assistance. It is quite immaterial what view one holds regarding the origin of meteorites. Astronomy, supported by the spectroscope, has shown that the universe is formed of the same elementary materials thruout; so whether one regards meteorites as shattered stars or shattered planets, nebular knots or condensed comets, as bolts from the Sun or as bombs from terrestrial volcanoes, the important fact for us is that *meteorites bring to our notice a type of rock existing in the solar system but different from anything that occurs in the outer shell of our planet;* and this material has just the sort of composition that petrology, geophysics, and astronomy combine to indicate as likely to be found in the interior of the Earth. For this reason, the study of meteorites has an extraordinary interest for the petrologist, and no discussion of eruptive rocks can be complete which ignores this fascinating aspect of the subject."

The Giacobinid Meteoric Shower of 1946 October 9/10

Harvard College Observatory Announcement Card 756 (dated 1946 June 19) contains the following statement from Dr. Leland E. Cunningham of Berkeley, California, concerning the Giacobinid meteors: "The Earth will cross the orbital plane of Periodic Comet Giacobini-Zinner on 1946 October 10, $03^h.0$ U.T., at a distance of 132,000 miles from the orbit, but will be 1,000 miles closer $0^h.5$ earlier. It will remain within 500,000 miles of the orbit, which was approximately the distance during the meteor shower of 1933, from 1946 October 9, $12^h.5$ U.T., to October 10, $16^h.5$ U.T., some 28 hours. Observations of the comet during the next 3 months may alter these figures slightly." *Cards 755* and *756* give an ephemeris of the comet, computed by Cunningham, and extending from 1946 June 13 to November 12.

All persons interested in the astronomical aspects of meteoritics should be prepared to observe the shower of Giacobinid meteors that will probably take place on the night of 1946 October 9/10. (See, in this connection, the discussion regarding the Giacobinids in Fletcher G. Watson's *Between the Planets*, pp. 128-30, 1941; in particular, the final paragraph of that discussion.)

Second Notice of the Ninth Meeting of the Society

As announced in the June issue (*C.S.R.M., P. A.*, **54**, 315-16, 1946), the Ninth Meeting of the Society (the first to be called since the close of the war) will be held on Monday and Tuesday, September 9 and 10, 1946, at Flagstaff, Arizona, and at the Canyon Diablo Meteorite Crater. The Arizona State College at Flagstaff, thru the kindness of its president, Dr. T. O. Bellwood, will be the headquarters of the meeting, which will open at 9 o'clock on Monday morning, September 9. The September 9 sessions will take place in Flagstaff and those of September 10 at the Crater. Members of the Society are asked to send the Secretary, at their earliest opportunity, and by September 1, at the latest, the titles and ab-

stracts (in form for publication in *C.S.R.M.*) of any papers that they may wish to present at the meeting.

Any person who is interested in meteoritics is cordially invited to attend the meeting, all sessions of which (except those of the Council) will be open to the public.

C. H. CLEMINSHAW, *Secretary*

President of the Society: LINCOLN LA PAZ, Department of Mathematics and Institute of Meteoritics, University of New Mexico, Albuquerque
Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, P. O. Box 9866, Los Feliz Station, Los Angeles 27, California

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By **LEON CAMPBELL, Recorder**

David B. Pickering: Never more shall we be greeted with the hearty handshake and stentorian voice of David B. Pickering, amateur astronomer and friend of all those with whom he came in contact. With his death on June 13, 1946, the AAVSO lost one of its best known and most beloved Patrons and members. He passed away at his home in East Orange, New Jersey, after a prolonged illness.

Born in Elmira, New York, on January 18, 1873, he spent most of his life in New Jersey. He graduated in 1889 from Newark Academy, soon after joined the jewelry firm of Henry Black and Company of Newark, and later served as its vice president until his retirement in 1926, but remained as director until last January.

Pickering was a man of many and varied accomplishments, not only as an expert photographer, a charming writer, and in later life a painter of much talent, but principally as an amateur astronomer of considerable renown, having been interested in the stars from the early age of fourteen. He had erected on the roof of his home a well-equipped observatory, where it remained for many years as a landmark and an inspiration to many amateur astronomers, and where many visitors had the opportunity to stargaze under his guidance. He was one of the active observers of the AAVSO almost from its inception; its first president when the association was formally organized in 1917, and again served in the same capacity in 1928-29.

It is due mainly to the efforts of "Dave," as he was familiarly known to so many, that the association adopted and executed the chart program which has served so effectively over the years. It was he who put the charts on a well-planned system, thus greatly facilitating the progress and accuracy of the work of estimating the brightness of the extensive list of variable stars on the AAVSO program.

"Dave" became so keenly interested in the discovery of bright novae that he sponsored for many years the awards of several gold medals, known as the David B. Pickering Nova Medal.

A man of dynamic personality and an able speaker, he did much to further the interest of the amateur in astronomy, not only through lectures and radio talks, but also through his travels and writings. He visited many of the world's observatories, both amateur and professional, and the delightful accounts of his travels appeared in many issues of POPULAR ASTRONOMY, under the title of "The Astronomical Fraternity of the World." He was a member of several astronomical societies besides the AAVSO. Chief among these were the American Astronomical Society, the Royal Astronomical Society of England, and the Société Astronomique de France. For several years he served on the Variable Star Commission of the International Astronomical Union, attending its meetings in Leyden, Holland, and Cambridge, Mass. For a number of years he served as a member of the Harvard Observatory Visiting Committee. In 1938 he was the recipient of the Fifth Merit Award of the AAVSO, the citation reading: "In appreciation of his long leadership in developing the Association and standardizing its methods, and, through travel and writing, spreading the gospel of international good will and cooperation in scientific work."

At the age of 60, Pickering took up painting as a hobby, both in watercolor and oils, and acquired skill in the art to such an extent that many of his still-lifes and landscapes were exhibited in several salons in New Jersey. His eldest son, James Sayre Pickering, bids fair to follow in the footsteps of his father as a variable star observer and writer on popular astronomy.

With the death of David B. Pickering, the ranks of the "Old Guard" of the AAVSO are being sadly depleted, and he will be sorely missed at future meetings of the Association, both by old and new members. He had experienced a well-rounded life, and the one regret of his many friends is that his passing could not have been made easier. To quote a passage which Pickering himself once wrote: "It is done. All is set. And from the quiet world, out goes a spirit once more—out among the stars."

Supernova, B Cassiopeiae: Dr. Baade of the Mount Wilson Observatory presents in the *Astrophysical Journal* for November, 1945, an excellent light curve of the supernova of 1572, known as Tycho's Nova. Tycho was not the original discoverer of this nova, but because he was the one who had observed and studied it so assiduously, his name has been attached to the star. It was first detected by Schaler on November 6, 1572, and by numerous other observers during the succeeding nights. Tycho discovered it on the 11th.

It is not to be wondered at that the sudden appearance of the star caused considerable excitement among contemporary scholars, especially when it attained a brilliance equal to that of Venus—magnitude minus four—and was for a time visible to the unaided eye in broad daylight. The star remained a brilliant object for many months, and not until more than a year had elapsed did it reach the sixth magnitude.

Dr. Baade has carefully evaluated the various magnitude estimates of the nova from November, 1572, to February, 1574, and illustrates the light changes by a curve which closely resembles that of the supernova of 1604, and other such novae of Type I. In spite of the seemingly crude estimates of Tycho, the resultant curve by Baade is remarkably smooth. A typical feature of this type of supernova is that the linear decrease in brightness which begins about six months after maximum is characterized by a gradient of +0.0137 magnitude per day, and B Cassiopeiae fitted this gradient perfectly from phase 120^d to 460^d.

Dr. Baade points out that the supernova of 1572 brings to three the number of supernovae of Type I which have been observed in our own galaxy within the last nine centuries; those of 1054 and 1604 being the other two. Both of these stars appeared in regions now occupied by expanding nebulosities; the one of 1054 undoubtedly produced the Crab Nebula. But no such nebulosity appears to occupy the place of B Cassiopeiae. It is estimated that if such a nebulosity does exist, its surface brightness must be fainter than magnitude 25 per square second of arc. It is hoped that the stellar remnant of this star—at least below magnitude 19—may be found when the 200-inch telescope is ready for use. Would that another such supernova might appear in our own galaxy in the not too distant future!

Rho Cassiopeiae: Word received from Dr. Popper at McDonald Observatory called attention to the recent decrease in magnitude of Rho Cassiopeiae, together with a note on its spectral characteristics. The star has been known as an irregular variable for many years, varying usually between the fourth and fifth magnitudes, according to Schneller's Catalogue, with spectral class cG5. Latest estimates give the visual magnitude as 6.0.

The star has been under rather close observation, especially during the past three years, by Joseph Ashbrook and by Edward Oravec of the AAVSO. Ashbrook's observations indicate an irregular change in brightness between magnitude 4.8 and 5.5, extending from December, 1943, to September, 1945, inclusive. Oravec's observations from September, 1945, to date indicate a rather steady decrease in light from magnitude 4.9 to 6.0. Visual observations of brightness are much desired and should preferably be made with a low-power binocular in order to separate the variable from its 6th magnitude companion. Estimates with the unaided eye would involve the combined light of the two stars, and produce a resulting magnitude decidedly too bright.

In the following table ten-day mean values are given, as deduced from observations by Ashbrook from J.D. 2431054 through J.D. 2431699, and by Oravec from J.D. 2431702 through 2431971.

RHO (ρ) CASSIOPEIAE

10-DAY MEANS

Mean J.D.	Mean Magn.	No. Obs.	Mean J.D.	Mean Magn.	No. Obs.
2431054	5.02	1	2431321	5.04	4
59	5.10	7	30	5.04	2
71	5.09	3	41	5.00	3
78	5.18	6	50	5.24	1
89	5.18	4	58	5.16	3
1101	5.01	6	71	5.29	2
10	4.96	4	79	5.32	6
19	4.88	4	89	5.34	7
28	4.99	2	1400	5.24	7
40	5.04	4	09	5.40	7
48	4.96	2	18	5.36	4
62	4.97	3	28	5.29	6
73	4.91	3	43	5.51	2
76	5.00	1	48	5.31	2
94	5.09	1	59	5.28	4
1209	5.00	1	68	5.04	3
58	5.02	2	79	5.03	3
91	5.15	3	89	5.01	6
96	5.15	2	1502	4.98	2
1310	5.31	2	08	4.86	2

Mean J.D.	Mean Magn.	No. Obs.	Mean J.D.	Mean Magn.	No. Obs.
2431520	4.94	3	2431702	4.9	1
31	4.89	3	06	4.9	1
36	4.88	1	29	5.1	1
46	4.88	1	1822	5.6	1
1600	4.88	2	33	5.6	1
33	4.84	1	43	5.6	1
40	4.86	2	51	5.70	2
48	4.84	1	70	5.75	2
66	4.84	1	83	5.9	1
77	4.96	2	91	5.8	1
94	5.00	1	1907	5.8	1
99	5.05	4	71	6.0	1

Nova (T) Coronae Borealis: True to form, the recurrent Nova (T) Coronae Borealis, which flared up for the second time in February of this year to nearly the third magnitude, after an interval of nearly eighty years (see these Notes in April POPULAR ASTRONOMY) is repeating its earlier performance of rising to a secondary maximum, such as occurred about three months after the original outburst in 1866.

Late in May the nova began a more or less steady rise from around the 10th magnitude, and by June 23 had attained magnitude 8.0, only slightly less bright than the corresponding maximum of 1866. Should the star continue to behave as is did on the previous occasion, it may be expected to remain at or near the 8th magnitude for several months, and then in the course of a few years it will fade away gradually to its normal stage, near the 10th magnitude. Curiously enough, Kukarkin and Parenago in 1933 predicted that the star might have a second outburst in the course of 60 to 100 years, and 80 years has proved to be the mean!

Antares, α Scorpii: It was pointed out by Parengo and Kukarkin in 1935 that α Scorpii appeared to vary to the extent of nearly a magnitude, in a period of 1733 days. Since the physical properties of α Scorpii closely resemble those of α Orionis—Betelgeuse—the confirmation of variation in α Scorpii is not surprising.

Mr. Joseph Ashbrook suggests that Antares be kept under close visual observation by observers south of the border, since for observers in the United States and Europe the star is too near the southern horizon for satisfactory observation. The following comparison stars are available for use:

Star	Magn.	Spec.	Star	Magn.	Spec.
α Cen	0.1	G0 + K5	α Cru	1.0	B1
β Cen	0.9	B1	γ Cru	1.6	Mb
α Aql	0.9	A5	ε Sgr	2.0	A0
			β Gru	2.2	Mb

Because of the large distance of α Scorpii from its comparison stars, care should be taken to make estimates only when α Scorpii and the star with which it is being compared are at approximately equal altitudes. Also, because of the slowness of the variation, observations should be continued over several years.

Observations for May and June: A total of 5,714 observations—2,220 in May and 3,494 in June—were contributed by 68 observers, as listed herewith:

Observer	May—1946—June No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	May—1946—June No. Var.	No. Ests.	No. Var.	No. Ests.
Adamopoulos	..	..	8	8	de Kock	80	421	89	420
Ahnert	..	..	4	147	Koons	42	46	24	25
Ashbrook	10	19	8	10	Ledbetter	..	..	20	22
Ball	26	30	..	..	Lee	1	1	..	..
Battle	..	..	2	4	Luft	..	..	20	110
Bappu, M.	..	..	20	35	Mallett	..	..	12	16
Blunck	34	40	52	64	Marshall	1	1	..	..
Boone	18	22	18	18	Mary	10	10	..	..
Bouton	9	12	10	17	Meek	..	..	27	108
Braitberg	9	28	..	..	Nadeau	26	32	64	85
Buckstaff	17	30	19	39	Oheim	53	74	22	22
Chandra	..	..	67	89	Oravec	30	97	33	99
Chassapis	..	..	82	126	Pardon	..	..	1	1
Cilley	24	50	..	..	Parker	28	28	17	17
Cousins	32	94	..	..	Parks	22	39	21	35
Dafter	..	..	9	30	Peltier	89	156	102	156
Elias	..	..	70	406	Petzold, H. E.	..	..	2	2
Fernald	148	268	169	326	Petzold, H. R.	..	..	40	101
Fleischer	..	..	2	2	Plakidis	..	..	18	18
Flower	5	9	2	6	Renner	51	51	..	..
Focas	..	..	35	50	Rosebrugh	16	74	15	76
Garneau	..	..	6	6	Schoenke	..	..	13	14
Gossner	15	47	..	..	Segers	15	36	21	40
Greenley	..	..	4	5	Sill	..	..	48	48
Halbach	..	..	35	37	Smith, J. R.	8	8	4	4
Harris	12	12	8	8	Stahr	..	..	24	30
Hartmann	114	126	118	146	Taboada	12	12	..	..
Holt	..	..	15	63	Topham	23	24	..	..
Houston	5	41	3	33	Wade	3	11	4	12
Howarth	17	17	..	..	Webb	13	17	15	17
Hukill	3	25	3	34	Weber	28	28	19	19
Irland	8	32	..	..	Welker	..	..	7	7
Kelley, M.	1	2	..	..	Zirin	38	44	37	66
Kelly	10	11	13	15					
Kitley	36	95	49	200	68 Totals		2220		3494

July 10, 1946.

General Notes

Dr. Leland E. Cunningham who contributes Planet Notes to this magazine from month to month has been appointed Assistant Professor in Astronomy at the University of California.

Dr. John A. Miller passed quietly away at his home in Wallingford on Saturday night, June 15, 1946. He had reached the age of eighty-six. For the past forty years Dr. Miller has been connected with Swarthmore College, from 1906 till 1929 as professor of mathematics and astronomy; from 1914 till 1929 he was also Vice-president of the college. From 1929 till 1936 he was Director of Sproul Observatory and research professor of astronomy; after 1936 Director of Sproul Observatory and Professor of Astronomy, Emeritus.

Dr. P. Swings, Professor of Astrophysics in the University of Liége, Belgium, on June 13, 1946, addressed a joint seminar of the Departments of Physics and Astronomy of the University of California, Los Angeles, on the subject of "The Line Spectrum of the Solar Corona."

Cordoba Observatory Diamond Jubilee

Invitations have been issued jointly by the Cordoba Observatory and the Argentine Physical Society to a scientific meeting to be held on September 20-23, 1946, in commemoration of the seventy-fifth anniversary of the founding of the Cordoba Observatory by President Sarmiento and Director Gould.

Watson's Scientific Computing Laboratory.—This Laboratory, now a part of Columbia University, is organized to offer instruction in the various phases of computation by mechanical devices. These courses will be offered for the first time in the Winter Session of 1946-1947. This Laboratory is under the direction of Dr. Wallace John Eckert, well known to astronomers because of his recent connection with the *American Ephemeris and Nautical Almanac.*

A Large-Scale Lunar Map

Recently Mr. H. Percy Wilkins, F.R.A.S., 127 Eversley Avenue, Barnehurst, Kent, England, has completed the drawing of a large-scale map of the moon upon which he has been working for a number of years. The original drawing is 25 feet in diameter, and naturally, therefore, permits of a very great amount of detail. For convenience this map is being reproduced in twenty-five sections on one-third of the original scale. Each section is twenty inches square. These sections may be had singly, or as a set, from the author, whose address is given above, at 1/4 for single sections, or 30/- for the set of twenty-five.

Having seen copies of the charts, I can testify as to the usefulness they have for anyone making a detailed study of the lunar surface. One might spend many years in identifying the numerous features portrayed on the map.

The amount of work necessary to the preparation of so detailed a map is well-nigh incredible. C.H.G.

Amateur Weathermen of America.—Under this title an organization has been formed recently at the Franklin Institute, Philadelphia. This organization is designed to consist of an association of all followers of the ways of the weather. Its purpose is to enlarge our understanding of weather and climate and to apply this information for the greater enjoyment of life. The Amateur Weathermen is an agency for the exchange of information, both technical and popular, among all interested individuals and groups of individuals. It is especially concerned with all projects that will enlarge the scientific outlook of the Youth of America. All who enjoy studying any aspect of weather phenomena are eligible for membership and participation in its activities. Those desiring further information should address their inquiry to:

Amateur Weathermen of America
% David M. Ludlum
The Franklin Institute
Philadelphia 3, Pennsylvania

Errata in "German Astronomy During the War" in June (1946) Issue

Through a delay due to the railways strike the corrected proofs were not received in time; following are the principal corrections.

Page 263, last paragraph. Read: The Rechen-Institut has been responsible for four major (and some minor) functions and publications.

Page 275, line 7 from top. Read: Sunspot Groups.

Page 275, line 20 from top. Read: had run for four years.

Page 275, line 5 from bottom. Read: halogenid crystals.

Page 280, line 4 from bottom. Omit first "n."

Page 281, line 16, from bottom. Read: Dr. Beileke.

Page 283, line 4 from top. Read: Bezugssysteme.

Page 283, line 6 from top. Read: Abh. (not Anh.)

Page 283, line 18 from top. Read: Heidelberg.

Page 283, line 28 from top. Read: *A. N.*, **272**, 78.

Page 285, line 13 from top and lines 6, 13, and 15 from bottom, omit asterisks.

Page 285, lines 22 and 24 from top, add asterisks.

The Cleveland Astronomical Society

The meeting of the Cleveland Astronomical Society held on June 7 was the last meeting of the Society for the season and was preceded by the annual dinner held at the College Club.

Dr. Paul Herget, of the Cincinnati Observatory, addressed the meeting. His topic was "Comets." Dr. Herget suggested that his topic could just as well have been "Gravitation" as "Comets." He proceeded to apply what is involved in the expression, "What goes up must come down" to such things as a baseball thrown into the air, a projectile shot from a gun, and a swinging pendulum. Kepler's laws regarding our Solar System and how they were arrived at was next discussed. The speaker then went into Newton's laws of motion and gravitation. These were all carefully explained for the layman. For those mathematically inclined involved mathematical expressions were written on the blackboard.

The earth was treated as a falling body, falling in toward the sun 1/9 inch every second while traveling 18½ miles each second approximately perpendicular to this direction. The resultant path of the earth is an ellipse. It was pointed out that the nature of the path followed by a boulder, planet or comet falling in toward the sun depends on its own initial velocity. At the velocity of the earth, 18½ miles per second, this path is an ellipse, at a velocity of 26 miles per second it becomes a parabola, at higher velocities it becomes a hyperbola.

The speaker brought his lecture up to the minute by introducing rockets. He showed that if a rocket could be given the right speed in the right direction at the right time while in its flight its path would become an ellipse large enough not to intercept the earth. The rocket would then not return to earth but become a satellite of the earth.

An interesting question period in which a great deal of speculation and imagination was brought to play followed the lecture.

HENRY F. DONNER.

Western Reserve University, Cleveland 6, Ohio.

American Astronomical Society

On the invitation of Dr. Joel Stebbins, the seventy-fifth meeting of the Society will be held at the Washburn Observatory and the University of Wisconsin at Madison September 8 to 11.

TENTATIVE PROGRAM
(Central Standard Time)

SUNDAY, SEPTEMBER 8

4:00 P.M. Registration begins
5:00 P.M. Council meeting
8:00 P.M. Opening gathering at the Observatory Residence

MONDAY, SEPTEMBER 9

9:00 A.M. Session for papers
2:00 P.M. Business meeting; election of officers
2:30 P.M. Session for papers
7:00 P.M. Boat ride
Evening At Washburn Observatory

TUESDAY, SEPTEMBER 10

9:00 A.M. Session for papers
2:00 P.M. Session for papers
7:15 P.M. Society dinner, $1.50

WEDNESDAY, SEPTEMBER 11

9:00 A.M. Final session

One of the sessions will be devoted to the Teachers' Conference. A second Council meeting will be scheduled in the final program.

HOUSING AND MEALS

Space has been reserved for the Society in some of the Men's Dormitories on the lake shore. These provide simple quarters with two single beds to a room and communal bathrooms (on different floors for men and women respectively). Meals will be served cafeteria style and, owing to shortage of help, meal hours will be limited to the intervals: 7:30 to 7:45; 12:30 to 1:00; and 6:00 to 6:30.

A flat rate of $10.00 has been arranged for the three nights, Sunday, Monday, and Tuesday, and seven meals—three on Monday and breakfast and lunch on Tuesday and Wednesday. (The dinner Tuesday night is extra, $1.50, and no meals will be served Sunday.) A key deposit of 50 cents will be required. Linen, towels, and soap will be furnished, as well as maid service (but not "room service"). There is parking space nearby and a pier for bathing is only a hundred feet from the dormitories. Occupancy may begin not earlier than 4:00 P.M. Sunday.

Supper may be obtained Sunday evening at the Union Cafeteria.

To make reservations, please communicate with Dr. C. M. Huffer. All reservations should be in by August 20.

The A. Cressy Morrison Prize in Astronomy

The following paragraphs are taken from the Report of the A. Cressy Morrison Prize Committee, Roy Waldo Miner, Chairman, issued at the close of last year.

"The Committee announces, on behalf of Mr. Morriston, that he has offered an Astronomical Prize, in renewal of those awarded in recent years, in the sum of $500.00 for the paper, adjudged by the Council of the Academy, to be the most meritorious contribution on the subject of solar and stellar energy. In connection with this offer, the following statement has been prepared:

"Understanding of the source of solar and stellar energy begins with Helmholtz's contraction theory (1854). As the primordial star contracts, the kinetic energy of the mass particles closing in under the force of gravity is transformed into heat energy. Whereas this is still believed to be cosmologically the first cause of stellar radiation, it has been realized since the end of the previous century that the process of contraction would run to its end in a time that is short as compared to the age of the earth; and, ever since this was realized, astronomers have been compelled to postulate that the Helmholtz contraction must be retarded and, for the major part of the life of the star, probably balanced by an internal pressure caused by energy that does not derive from kinetic energy. The way out of this difficulty was cleared theoretically (1905) by Einstein's law of the equivalence of mass and energy, although the exact mechanism whereby, under stellar conditions, matter would change into radiation, remained still a secret. The first laboratory transmutation of nitrogen into an isotope of oxygen by Rutherford (1917) opened the field of nuclear reactions which led to the experimental results; namely, that the mass lost in a nuclear reaction and the energy set free are in accordance with Einstein's law. By examining all possibilities of reactions that could take place under conditions prevailing in the sun, Bethe (1939) succeeded in singling out the one reaction that should, both as to the requirement of temperature and as to the availability of the elements involved, take place at the proper rate. This is the so-called carbon cycle whereby the energy liberated is equivalent to the mass defect of the helium atom as compared to four hydrogen atoms.

Prodigious progress has been made since the first A. Cressy Morrison Prize on the above subject was offered in 1926. It is, however, felt that the complete answer has not yet been given and many questions remain open. In the first place, no final model for the sun, properly satisfying the observed luminosity and the hydrodynamical considerations, has been published. Secondly, at best a start has been made on the problem of the so-called "red giants," "sub dwarfs," and "white dwarfs." Through the continued interest of Mr. Morrison and his desire to stimulate further research in the subject, the above prize will be renewed for award in 1946.

The Teaching of Science and Mathematics

The developments accelerated by World War II brought into stark, dramatic focus the need of understanding and appreciation of science and mathematics by every citizen of our country.

For many years the adequate teaching of these subjects has been urged and planned for by many groups and associations of local, regional, and national scope. More recently a Cooperative Committee representing many of these groups

began to function, and in 1945 it became officially a committee of the A.A.A.S.[1]

Under the general control and the vast prestige of the Association, this Cooperative Committee is proceeding to define and to activate its agenda. All the physical and natural sciences, and mathematics are now represented on this committee. At the discretion of the Association various large organizations of the personnel of these basic fields are or may be represented.

In report No. 4 of The A.A.A.S. Cooperative Committee on Science Teaching[2] (first published in *School Science and Mathematics*, February, 1946) the main thesis and recommendations were laid down. It has chiefly to do with the teaching situation in primary schools and small high schools. Of the latter, in the whole country, one-half have five teachers or less, three-fourths have ten teachers or less.

The theses are:

1. Science teachers are not properly trained for the actual teaching assignments they must accept as beginning teachers working for the most part in small high schools.
2. Not enough able men and women are attracted to science teaching in the schools, because salaries are indecently low and the job lacks dignity.
3. The high school science curriculum needs a thorough-going reorganization and the material equipment for science teaching needs modernizing.

Blame for the first lies with the universities and colleges; for the second especially, but also for the third, it lies with the American public.

Five recommendations follow:

1. A policy of certification in closely related subjects within the broad area of the sciences and mathematics should be established and put into practice.
2. Approximately one-half of the prospective teacher's four-year college program should be devoted to courses in the sciences.
3. Certificates to teach general science at the 7th, 8th, or 9th grade level should be granted on the basis of a broad preparation including college courses in all the subjects concerned in general science.
4. Colleges and certification authorities should work toward a five-year program for the preparation of high school teachers.
5. Curriculum improvements in the small high school should go hand in hand with improvement in teacher preparation.

A supplementary proposal.

In order to give teachers themselves and teacher-hiring officials a profile of a candidate's developing adequacy, it is proposed to establish sets of proficiency examinations, beginning while the teacher-to-be is still under training, and continuing for some years after he begins to teach. This proposal is one that could become controversial, but the Committee has evidence that schools, which have much to do with teacher-training, are friendly to the idea.

The obvious advantages of such a plan are:

1. The early elimination of a prospective teacher, who does not have the training, personality or attitude which predicts success in this activity.

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[1] The members of the Committee, nominated by their respective scientific societies, number 14.

[2] Copies of "Report No. 4, The A.A.A.S. Cooperative Committee on Science Teaching" may be had by addressing Dr. K. Lark-Horovitz, Chairman, Head of the department of Physics, Purdue University, Lafayette, Indiana.

2. The equally early recognition of excellence, and faster promotion into responsible positions of those who do.

The Committee emphasizes the need and desirability of close and constant cooperation of science departments in normal schools, colleges, and universities with educational associations and the Departments of Education in cities and states, and the Federal Government.

OLIVER JUSTIN LEE.

Representing the American Astronomical Society.

Book Review

An Introduction to the Study of Eclipsing Variables, by Zdeněk Kopal (Harvard University Press, Cambridge, Mass., 1946). This comprehensive book, No. 6 in the series of Harvard Monographs, is by an author who has devoted many years of his professional career to the study of the theory of eclipsing variables, and has contributed many papers on the subject. It is not a book to be lightly perused by the layman, but is intended especially for students and research workers in this particular field of investigation. There is a foreword by Professor Henry Norris Russell, who states that the memoir presents a comprehensive and accurate account of the present state of the theory of eclipsing binaries.

The book may be divided into two main parts: Chapters II to V treat of the geometrical problems—the model of an eclipsing system consisting of spherical stars—and Chapters VI to IX, of the dynamical—in which case distortion of the components is taken into account.

In Chapter I, the introduction, there is a résumé of the history of the discovery and theory of eclipsing variables, beginning, of course, with Algol, and treating of the significance of such variables in the problem of binaries as a whole. Chapter II discusses the geometrical aspects of the eclipses of spherical stars appearing as uniformly bright or limb-darkened circular disks, and is rather preparatory to the subsequent discussion in Chapter III of the actual problems to be encountered in practice. Chapter IV describes methods for improving a preliminary set for photometric elements, while Chapter V finally summarizes effects upon light curves arising from orbital eccentricity. Beginning with chapter VI the author makes a different type of approach, dealing with distorted stars. In Chapters VII and VIII he deals with the theoretical light curves of very close eclipsing systems, and finally, in Chapter IX, he discusses methods for determining the element of these close systems.

The book is replete with bibliographical notes, appended to each chapter and intended only to amplify further the points mentioned in the text. As the title implies, it is an introduction to the study, and not an exhaustive treatise. It is a fitting companion to the previously published Harvard Monographs and should be in the hands of all students interested in eclipsing binary systems.

L.C.